APR 13 1925

ENGINEERING:

An Illustrated Weekly Journal.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXIX.—No. 3091.] *LONDON: FRIDAY, MARCH 27, 1925.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY INLAND POST 1s. 2½d.

Aveling & Porter, Ltd.,
ROCHESTER.
Steam & Crude Oil Road Rollers, &c. 2581

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches. BOILER FEED PUMPS.
See Advertisement page 67.
PATENT WATER-TUBE BOILERS. AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London."—Great Eastern Road, Stratford, E.15. 1794

Spencer-Hopwood & Kirke
PATENT BOILERS. 1994
See page 38.
Sole Makers: SPENCER BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES,
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 2633

See's Patent Hydro-Pneumatic Ash Ejector
Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWHNT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4836

ON ADMIRALTY LIST.

John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL St., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Branch Office and Depot: 14, SNOW HILL, BIRMINGHAM. 'Phone: Central 2775.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters. Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers, &c., &c. 2327

Travelling & Jib Cranes.
FELLOWS BROS., LTD., 2158
CRADLEY HEATH, STAFFS.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 2572

Steam Hammers (with or without guides). Hand-worked or self-acting TOOLS for SHIPBUILDERS & BOILERMAKERS. 2610
DAVIS & PRIMROSE, LIMITED, LEITH, EDINBURGH.

Bever, Dorling & Co., Ltd.,
BRADFORD.
HIGH-CLASS ENGINES FOR ALL PURPOSES, also WINDING, HAULING, AIR COMPRESSING and PUMPING ENGINES. 1906
GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED

Duckham's Patent Suspended Weighing Machines—East Ferry Road Engineering Works Company, Ltd.
LONDON, E.—Hydraulic Cranes, Grain Elevators, &c.
See illus. Advt. last week, page 17. 2430

CRANES. All Types.
GEORGE RUSSELL & CO., LTD., Motherwell. 2591
Telegrams:—"Cylinders," Birmingham.

Weldless-Steel Tubes
for Water-tube Boilers, Superheaters, Scalding, Hydraulic Work, Boring Rods, &c.
TUBES LIMITED, BIRMINGHAM. C8179

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 2276

Campbells & Hunter, Ltd.
SPECIALISTS IN
Drillers & Boring Machinery
for Engine Works and Boiler Shops.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & CO., LTD.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3551
ENGINEERS & BOILER MAKERS.

For Your Repairs or any
SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
Bridge Road West, Battersea, S.W.11.
Estd. 1854. 2703

The Mitchell Conveyor and
TRANSPORTER CO., LTD.,
CONTRACTING ENGINEERS.
DESIGNERS and BUILDERS
of
all Classes of HANDLING MACHINERY.
Atlantic House,
45-50, Holborn Viaduct,
London, E.C. 1.
Telegrams: "Micontraco, Cent, London."
Telephone: Holborn 3822. 2418

Dredging Plant—
For ALLUVIAL GOLD, PLATINUM & TIN, HARBOUR, RIVER & CANAL.—Gravel Dredgers, SCREENS.—DREDGE BUCKETS & Parts, all sizes.
ARTHUR R. BROWN,
54, New Broad Street, London, E.C.2.
Telephone: London Wall 3418. 2509

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.,
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

For Sale or to Feu, in Whole OR PLOTS.
68 ACRES OF GROUND AND BUILDINGS, suitable for Factories or Works, at Inchinnan, on the main road between Glasgow and Greenock.
One building, length 250 ft. by 150 ft., height 48 ft. to eaves, structure of brick and steel, lit from roof, contains approximately 37,500 sq. ft. floor space.
One building, in several bays, 330 ft. long at the longest part, 258 ft. broad, height, one part 24 ft. 6 in. to eaves, other part 16 ft. to eaves structure of brick and steel, lit from sides and roofs, granolithic floors, mechanically heated, contains approximately 83,000 sq. ft. floor space.
One building 320 ft. long by 160 ft. broad, height, 16 ft. 9 in. to eaves, with small annex 50 ft. by 30 ft., structure of brick and steel, granolithic floors, lit from sides and roof, mechanically heated, approximately 53,000 sq. ft. floor space.
Electric power is laid into each of these buildings from the Clyde Valley Power Station, also water supply.
For further particulars apply to:—
WEARING & MARTIN, Writers, 180, Hope Street, Glasgow. 2346

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 33.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS. } ROW'S PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

IRON & STEEL
Tubes and Fittings
AND
Steel Plates.
Stewarts and Lloyds, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisements, pages 66 and 102. 2584

Cement—Maxted & Knott,
Ltd., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD ADVICE ONLY. Highest references. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 1828

James D. Roots.—Patents,
BRITISH and FOREIGN. Moderate charges. Long and varied practical Engineering experience valuable to inventors. Formerly many years contributor of Patents Abstracts for "The Engineer" & "The Times."—Thanet House, Temple Bar, London, W.C.2.

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, AND EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS. Od 3382
Reg. Office and Chief Works: Motherwell. London Office: 33, Great St. Helen's, Bishopsgate, E.C.3.

Belliss Three-crank Compound
ENGINES, 500 Kw., Dynamos 230 Volt D.C. Brush, Parsons 600 Kw., EXHAUST TURBINE SET 220 Volt, D.C., with complete condensing plant. Very low price.
JENNINGS, 3402
West Walls,
Newcastle-on-Tyne.

Regent Shears and Presses
FOR SHEET AND PLATE WORKING.
THE REGENT SHEET METAL MACHINE TOOL CO., LTD.,
REGENT WORKS, WAKEFIELD. 2704

TRADE "SUMMIT" MARK.
Slitting Saws
AND SCREW SLOTTING CUTTERS.
JOSEPH THOMPSON (Sheffield) LTD.,
Townhead Street Engineering Works, SHEFFIELD. 2677

PROPELLERS
AND PROPULSION PROBLEMS.
Special designs only.
"Circulation Theory."
Akimoff Propeller Company,
PHILADELPHIA, U.S.A. 2349

British Bock Bearings,
LIMITED.
Works and Offices: 120, Cornwall Street, Glasgow.
Branch Office: 4, Albert Square, Manchester.
Regd. Offices: 10, Princes St., Westminster, S.W.1.
Adjustable Taper Roller Bearings. 2608

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 2277

John Bellamy, Limited,
MILLWALL, LONDON, E. 1316
GENERAL CONSTRUCTIONAL ENGINEERS.
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Head, Wrightson & Co.,
LIMITED
See Advertisement page 58, March 27. 2402

P. & W. MacLellan, Ltd.,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 3547
Registered Offices: Clutha House, 10, Princes St., Westminster, S.W.1.

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2702

WAYGOOD-OTIS LIFTS 2130
54 & 55, FETTER LANE, LONDON, E.C.4.
62 & 63, LIONEL STREET, BIRMINGHAM, and Principal Provincial Cities and Abroad.

New Wire Ropes,
Half price. Send for list.
LONDON ELECTRIC FIRM.
Croydon. 2723

Machine Tool Bargains
comprising:

LATHES	GEAR-CUTTING	SLOTTING AND
MILLING	PLANING	BORING
DRILLING	SHAPING	MACHINES.
GRINDING		

Write for Surplus List No. 13.
Alfred Herbert Ltd.,
'Phone: 860 (3 lines). COVENTRY. Wires: Lathe, Coventry. H 301

BARGAINS FROM BOLTON.
Nearly New Pair of Self-contained HAULING ENGINES, by John Wood & Sons, Wigan.
Cylinder..... 12 in. diam.
Stroke..... 20 in. diam.
Very heavy cast-iron bedplate.
Double Helical Gearing. Link reversing motion, Winding drum, 4 ft. diam. by 3 ft. 6 in. wide. Flange 9 in. deep.
IN STOCK
THOMAS MITCHELL & SONS, LTD.
BOLTON. 2405

The Manchester Steam Users ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Worshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2701

The Manchester Steam Users' ASSOCIATION.

The ANNUAL GENERAL MEETING of the Members was held in the Board Room of the Association, at their Offices, 9, Mount Street, Manchester, on Tuesday, March 24th, HAROLD LEE, Esq., J.P. (Manchester), President, in the Chair, when the following resolutions were adopted:—

Moved by the CHAIRMAN, seconded by J. T. BROWNE, Esq., Pendlebury (Vice-President), and resolved:—

"That the Report of the Committee of Management to the Subscribers, along with the accompanying Financial Statement, be and is hereby approved and adopted."

Moved by A. E. MALPAS, Esq. (United Alkali Co., Ltd., Widnes), seconded by EDWARD TURNBULL, Esq. (Messrs. Tate & Lyle, Ltd., Liverpool), and resolved:—

"That the thanks of the Association are due and are hereby presented to the Committee of Management for their past services, and that the following gentlemen be elected the Committee for the ensuing year, with power to add to their number:—

COMMITTEE OF MANAGEMENT.
HAROLD LEE, Esq., J.P., Manchester.
A. NORMAN DUGDALE, Esq., J.P., Blackburn.
JAS. STANLEY ADDISON, Esq., London.
J. T. BROWNE, Esq., Pendlebury.
ALFRED H. J. COCHRANE, Esq., Openshaw.
CHARLES W. CROSSLEY, Esq., J.P., Halifax.
CHARLES ROBERTS, Esq., Manchester.

Moved by T. HUTCHINSON, Esq. (Fine Cotton Spinners' & Doublers' Association, Ltd., Manchester), seconded by W. A. WORDLEY, Esq. (Bradford Dyers' Association, Ltd., Bradford), and resolved:—

"That Messrs. F. W. POPPLEWELL & SON, Chartered Accountants, Manchester, be appointed Auditors of the Association's accounts for the year 1925."

JAMES PARR, Secretary,
9, Mount Street, Albert Square, Manchester.
25th March, 1925. H623

Northampton Polytechnic INSTITUTE,

St. John Street, Clerkenwell, E.C.1.

ENGINEERING DAY COLLEGE.

ENTRANCE EXAMINATIONS,
Session 1925-26.

Entrance Examination in connection with the Engineering Day College of the above Institute will be held as follows:—
Tuesday and Wednesday, April 21st and 22nd.
Tuesday and Wednesday, September 22nd and 23rd.

Each Examination provides for admission at the commencement of the Autumn Term, 1925, the April examination being specially designed to meet the convenience of intending students who desire to ascertain in advance their position in regard to admission.

Further information may be had on application to
THE PRINCIPAL.
H 576

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech., London Univ. (Matric., Inter., B.Sc.), Inst.M. & Cy.E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng. London, Assoc.M.Inst.C.E., Chartered Civil Engineer, M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 2689

Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 766

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Milligate Building, Manchester. 3676

TENDERS.

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, E.C.2, invite

Tenders for:—

1. BRASS AND IRON OR STEEL SCREWS, &c. ..... Fee 10s.
2. STEEL RAILS and FISHPLATES ,, £1.
3. BOLTS, NUTS, RIVETS, &c. ..... ,, 10s.
4. SPRING STEEL ..... ,, 7s. 6d.

Tenders are due by Eleven a.m. on 7th April, 1925. Tender forms obtainable at above address. Fees not returnable. H 618

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E. 1, invites

Tenders for:—

1. GIRDER BRIDGEWORK.
2. SURFACE TRAVERSER, Electric, 100 tons capacity. Overhead Electric Travelling Crane, 30 tons capacity.

Tenders due on the 15th April, 1925.
Tender Forms obtainable from above. H 609

The Proprietors of British

Patents No. 179560, relating to Reciprocating Steam Engines, and No. 179941, relating to Hydraulic Power Transmission, are PREPARED to RECEIVE TENDERS for the MANUFACTURE of the INVENTIONS in Great Britain, or to consider applications for the grant of licences thereunder.

Applications in the first instance should be addressed to KILBURN & STRODE, 31, High Holborn, London, W.C.1. H 634

ROYAL STATE RAILWAY DEPARTMENT OF SIAM.

Sealed Tenders for the Supply

of FITTINGS for WAGON CONSTRUCTION (including Angles, Plates, Flats, Corrugated Sheets, Bolts, Nuts, Washers, Door and Body Fittings), B.E. 2468, will be received by the undersigned at his Office up to 14 o'clock on Monday, the 29th June, 1925, at which place and hour the Tenders will be publicly opened and read.

Blank Tender Forms, Specifications and Plans may be obtained from Messrs. C. P. SANDBERG, 40, Grosvenor Gardens, London, S.W.1, upon payment of £1 10s. per set, which sum will not be refunded.

Right is reserved to reject any or all Tenders and to accept any Tender which, in the opinion of the undersigned, is to the best interests of the Royal State Railways.

Royal State Railway Department of Siam,
PURACHATRA,
Commissioner General. H 597

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon, on Wednesday, 8th April,

Tenders for the Supply of:—

1. STEEL MATERIAL (PLATES, CHANNELS, ANGLES, ETC.).
2. WHEELS AND AXLES FOR WAGONS.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices on payment of 20/- each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France,
Westminster,
S.W.1. H 602
23rd March, 1925.

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

ELECTRIFICATION OF BOMBAY SUBURBAN LINES.

The Directors are prepared to receive

Tenders for the Supply and

ERECTION in India of the following Plant:—CABLES.

Fee for Specification £2 per copy.

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment *will not be returned*.

Tenders must be submitted in duplicate, and must be sealed and addressed to the undersigned, marked "Tender for Cables," and delivered not later than Noon, on Monday, April 20th, 1925.

The fee should accompany any application by post. Cheques and postal orders should be crossed and made payable to the Bombay, Baroda and Central India Railway Company.

The Directors do not bind themselves to accept the lowest or any Tender.

The Consulting Engineers, to whom application for any further technical information may be made, are Messrs. MERZ & MCLELLAN, 32, Victoria Street, Westminster, S.W.1.

S. G. S. YOUNG,
Secretary.

Offices: The White Mansion,
91, Petty France,
Westminster, S.W.1.
23rd March, 1925. H 601

APPOINTMENTS OPEN.

Applications are Invited

for a VACANCY as JUNIOR SCIENTIFIC ASSISTANT in the Experimental Department of H.M. Signal School, Portsmouth. Candidates, who should not be over 30 years of age, should possess an Honours Degree in Physics or its equivalent. (Preference will be given to ex-Service men.)

The salary scale is £175-15-235, plus Civil Service Bonus, which at present increases £175 to £278 19s.

The successful candidate will be required to contribute 5 per cent. of the basic salary under the Federated Universities Superannuation Scheme, the remainder being contributed by the Government.

Applications, giving full particulars of qualifications, War Service, etc., and enclosing testimonials, should be forwarded to the SECRETARY OF THE ADMIRALTY (C.E.), Admiralty, S.W.1, not later than April 7th. H 457

Commercial Manager Wanted

for large Iron and Steel Company in the North. To the right man liberal salary will be given of at least Two thousand pounds per annum, with prospects.—Write, CHAIRMAN, c/o J. W. VICKERS AND Co., Ltd., 5, Nicholas Lane, E.C.4. H 592

Assistant to General Manager

REQUIRED for an important Tramway system in South America. Must be thoroughly qualified to handle general direction of operating conditions, such as arranging time-tables, routing, fare collection, timekeeping, men, etc. Position offers good opportunity for advancement to a capable, reliable and experienced man. Good salary paid.—Write, in first instance, stating qualifications, to S. P., care Advertisement Department, 5, New Bridge Street, E.C.4. H 630

Commercial Manager Wanted

who could take entire management of an Engineering Business (Sales about £200,000 per annum) in the North of England; with experience in Electrical Engineering preferred.—Address, stating full particulars as to experience, salary required, with testimonials, H 595, Offices of ENGINEERING.

Wanted, Experienced

METALLURGIST for Steel Works in South Yorkshire. Applicant must be familiar with the manufacture, forging, rolling and general manipulation of alloy and carbon steels to the various standard specifications.—Address, stating age, qualifications and salary required, H 582, Offices of ENGINEERING.

Mechanical Metallurgist Re-

QUIRED for an experimental shop in the Midlands. A thorough knowledge of the theory and practice of the mechanical working of non-ferrous metals by cupping drawing, heading, etc., with experience of tool and machine design, and a clear insight into the physical changes taking place in a metal during its hardening by cold work and softening by annealing are essential. The position calls for sound progressive development and keen observational faculties based on mathematical, mechanical and metallurgical knowledge.—Apply, by letter only stating salary required, to KYNOCH LTD., Witton. H 577

THE GOVERNMENT OF THE PUNJAB require the services of an

Inspector of Draglines in

connection with the excavation of the Sutlej Valley canal. Must be expert excavating engineer, able to train operators in correct methods for efficient working of machines, to advise on repairs and supplies of spares, and to check consumption of stores in daily use, such as coal, lubricating oil, etc.

Four years' agreement. Salary at a rate to be fixed between Rs. 1000 and Rs. 1600 a month according to age and qualifications. First-class passage to India and return passage on satisfactory termination of agreement.

Forms of application and further particulars should be obtained from the Secretary to the HIGH COMMISSIONER FOR INDIA, 42, Grosvenor Gardens, London, S.W.1. Last date for receipt of applications, 10th April, 1925. H 610

Superintendent Engineer

REQUIRED for large Steam Fishing Company on the East Coast. Good Drawing Office experience essential; must possess extra Chief's ticket; Workshops experience an advantage. Only energetic capable men with initiative, who are prepared to exercise strict supervision, considered.—Apply, in first instance, stating age, qualifications, salary required, when at liberty, and forward copies of recent testimonials to BOX 1170, MORISON'S Advertising Agency, Hull. H 587

Junior Electrical Engineer

REQUIRED in London Office of progressive firm. Graduate preferred with shop and D.C. training. Experience in power and lighting distribution advantage. Good opening for right man. Only applications from London district considered.—Address, with full particulars, giving age, experience, and salary required, H 632, Offices of ENGINEERING.

Engineer Wanted by West-

minster Firm of Engineers in connection with engineering undertakings and railways at home and abroad. Age about 30. Sound theoretical and practical training essential, together with experience in dealing with the correspondence necessary to handle large contracts at home and abroad. Some practical experience of electrical work desirable but not essential. Salary £500 and upwards, depending upon experience and qualifications. Applicants should state age, salary required and whether married or single, and should furnish copy of at least one testimonial and give two references.—Address, H 584, Offices of ENGINEERING.

CITY OF BIRMINGHAM ELECTRIC SUPPLY DEPARTMENT.

ASSISTANT TO CONSTRUCTIONAL ENGINEER.

DRAUGHTSMAN.

Applications are Invited for

the following APPOINTMENTS:—

(1) ASSISTANT TO CONSTRUCTIONAL ENGINEER.

To assist in the preparation of Specifications and Plans for new buildings, lay-out of boilers, turbo-alternators, etc.

Candidates must be corporate members of the I.M.E. or of the I.Mech.E.

Salary—Class J, Grade 8, National Joint Board's Schedule. Present net amount £430 per annum.

(2) DRAUGHTSMAN IN CONSTRUCTIONAL ENGINEER'S DEPARTMENT.

Salary—Class J, Grade 9, National Joint Board's Schedule. Present net amount £342 per annum.

Candidates for both appointments must have served an apprenticeship to Mechanical Engineering and had experience of the latest practice as applied to the design of large Electric Stations.

The successful candidates will be required to undergo an approved medical examination and contribute to the Corporation's Superannuation Scheme.

Forms of application for these appointments may be obtained from the undersigned and will require to be returned with copies of not more than three recent testimonials by the 6th April.

E. J. JENNINGS,
Secretary.

14, Dale End,
Birmingham,
March 13th, 1925. H 528

The Advertisers for Power

Plant Engineers, under Box No. H 438, wish to thank all unsuccessful applicants. These positions are now filled. H 633

Wanted for Bombay a Good,

Capable TEMPLATE MAKER, used to Bridge and Constructional work. None but first-class men need apply.—State age, experience and salary required, to GENERAL MANAGER, BRAITHWAITE & Co. (Engineers) Ltd., West Bromwich. H 619

Estimator, able to make up

structural steel estimates from outline drawings, combining experience of mechanical handling plants for coal, ore, etc. Only experienced men need apply. State age, experience and salary required.—Address, H 533, Offices of ENGINEERING.

Assistant Engineer and

DRAUGHTSMAN WANTED, in Westminster, with sound Technical training and good experience in arrangement and detail design of heavy industrial machinery.—Address, stating age, experience, salary required, (no original testimonials), H 612, Offices of ENGINEERING.

Draughtsman Required in the

Rolling Stock Department of the Manchester Corporation Tramways. One accustomed to tramcar and motor 'bus work preferred. Commencing salary, basic, £185, plus Civil Service Bonus, £100, present total £285 per annum.—Applications, with three testimonials, to be forwarded to the GENERAL MANAGER and CHIEF ENGINEER, Corporation Tramways, 55, Piccadilly, Manchester, on or before Tuesday, the 7th April, 1925. H 621

A Leading Draughtsman

REQUIRED, capable of taking charge of the Reciprocating Compressor Section in Drawing Office. The position vacant is for a first-class man with initiative and organizing ability.

Reply, giving full particulars of previous experience and technical training, stating age and salary required, to REAVELL & CO., LTD., Ipswich. H 627

Head Draughtsman for Struc-

tural Works, Glasgow district. Must have sound theoretical and practical experience. Age between 30 and 40. Salary about £500 or over, according to qualifications.—Address, with full particulars, H 588, Offices of ENGINEERING.

Mechanical Engineering

DRAUGHTSMAN, not over 40 years of age, with good workshop experience, WANTED for temporary employment in the service of the London County Council.—Forms of application can be obtained from the CHIEF ENGINEER, Old County Hall, Spring Gardens, S.W.1, not later than 4th April, 1925. Canvassing disqualifies. Preference to those who served, or attempted to serve, with H.M. Forces. H 603

Wanted, Draughtsman-

Designer, used to Elevator Conveyors, Mechanical Handling Plant, as applied to Industrial uses.—Address, H 562, Offices of ENGINEERING.

Draughtsman, Skilled in

design and lay-out of mechanical handling plants for ore and coal.

Men without actual experience need not apply.—State age, experience and salary required.—Address, H 534, Offices of ENGINEERING.

Marine Engineering

DRAUGHTSMAN, CHIEF, WANTED for Far East, age over 30, five years' agreement; Salary £425 per month first 2½ years'; £450 per month second 2½ years; must be experienced in the designing of marine engines and boilers. Send testimonials and references, stating full experience, married or single.

Address, "MARINE," WM. PORTEOUS & Co., Advertising Agents, Glasgow. H 613

Wanted, Three Draughtsmen

with thorough knowledge of the design of heating and ventilating installations, domestic hot water apparatus and preferably, also vacuum cleaning plant.—Candidates when replying should submit details of their qualifications and practical experience, and should also send particulars of war service, together with recent references or testimonials, and state salary required, to G.E., c/o CHARLES BARKER and SONS, Ltd., 31, Budge Row, E.C.4. H 615

Required by Consulting

Engineer, in Westminster, First-class Designing DRAUGHTSMAN for Dock, Quay, Bridges and General work.—Address, Stating when disengaged, whether outside experience, Salary required, full particulars and testimonials, H 629, Offices of ENGINEERING.

Wanted for India Two Good

DRAUGHTSMEN, used to detailing all kinds of Bridge and Constructional work, also well up in the design of structures, taking out of quantities and preparing estimates.—Apply, stating age, particulars of experience and salary required, to GENERAL MANAGER, BRAITHWAITE & Co. (Engineers) Ltd., West Bromwich. H 630

Blue Printing.—Man to Take

Charge of Manufacturing Engineers' Blue Print Room and Drawing Files. Must have knowledge of Rotary Blue Printing Machines and modern Photostatic and Reproduction processes, together with experience of routine filing and card indexing.—Address, stating age, experience, and salary required, H 631, Offices of ENGINEERING.

TWENTY YEARS' WORK ON THE PENNSYLVANIA RAILROAD LOCOMOTIVE TESTING PLANT.

By LAWFORD H. FRY, M.Inst.C.E.

THE appearance recently of Bulletin No. 32 of the Pennsylvania Railroad locomotive testing plant is a reminder that this plant has now completed twenty years' of service. First installed at the St. Louis Exposition in 1904, the plant was set up permanently at Altoona at the close of the exhibition, and since that time has been extensively used by the Pennsylvania Railroad. Now, at the end of twenty years, it is interesting to look back and to note, briefly, the development of the Pennsylvania Railroad locomotives in this time, remembering that the locomotive testing plant has played an important part in the changes which have been made. Of the three locomotive testing plants in the United States, that at Altoona, which was the second to be installed, has been the most actively and the most intelligently used. The plant at the University of Illinois and that at Purdue University since Dr. Goss left, have published little which has added to our knowledge. The Altoona plant has, however, a continuous record of constructive work, and has done much to increase our knowledge in connection with the details of locomotive design and operation.

A testing plant makes it possible to test a locomotive with a uniformity of conditions and an accuracy of measurements which are entirely impracticable in a road test. As a consequence, the information obtained regarding the details of operation is much more definite than can be secured in road tests. Some unfamiliar with such plants have been known to express the opinion that the results obtained represent artificial conditions and are not directly applicable to service conditions. The experience of the Pennsylvania Railroad negatives this academic objection. As each new type of locomotive has appeared on the Pennsylvania system, it has been fully tested in the plant, its characteristic and capabilities determined, and the information thus obtained has been used in effecting improvements in succeeding designs. In many cases when a new type of engine was proposed, one engine has been built and tested, and, as a result, minor modifications have been made before the type was accepted for quantity production.

The first locomotive to be tested in the plant was the Pennsylvania Railroad No. 1499, a 2-8-0 or consolidation type locomotive, P.R.R. Class H6a. This engine, built in 1903, used saturated steam and weighed, in working order without tender, 194,000 lb. (87 tons). The latest engine to be tested is No. 4358 of the Pennsylvania Railroad Class H1s, which is of the 2-10-0 or decapod type. This engine is one of 475 built by The Baldwin Locomotive Works in 1922 and 1923 for the Pennsylvania Railroad. They are equipped with superheaters and Worthington feedwater heaters, and weigh, in working order, about 386,000 lb. (173 tons) without tender. The H1s Class is, as the H6a was twenty years ago, the heaviest standard type of freight locomotive on the Pennsylvania system. A comparison of the results given by the two locomotives in the testing plant is eloquent testimony to the growth and improvement that have been made in twenty years. The H6a locomotive developed a drawbar horsepower for each 202 lbs. of total weight, while with the modern H1s the weight required per drawbar horsepower has been reduced to less than 120 lb. The total locomotive weight has been doubled, while the drawbar horse-power has been increased in the proportion of 3·5 to 1. That is to say, each pound of locomotive weight is 70 per cent. more effective in producing drawbar pull than it was twenty years ago.

Close study will show that the locomotive has been improved both in the efficiency with which the steam is produced and in the efficiency with which it is used in the cylinders. Consider first the boiler performance. The boiler efficiency of a locomotive is dependent on two separate factors:—The efficiency of combustion, or the heat produced in relation to the heat in the coal fired; and the efficiency of heat absorption, that is the heat taken up by the boiler in relation to the amount of heat produced by combustion.

One of the most important things the locomotive testing plant has done is to enable us to separate these two factors. Before the testing plant went into operation it was well known that the efficiency of a locomotive boiler fell off rapidly as the rate of operation was increased. It was recognised that the temperature at which the gases escaped into the smoke box increased, and it was thought that the drop in efficiency was due to inability of the boiler to absorb the heat produced in the firebox. It was, therefore, natural to attempt to increase boiler efficiency by increasing the heating surface of the boiler. When the results on the locomotive testing plant were analysed, it was found that the rate of operation had little effect on the efficiency of heat absorption of the boiler. The drop in boiler efficiency is almost entirely due to an increase in the escape of unburned coal through the stack, which increases very rapidly as the rate of operation is increased. This information furnished by the locomotive testing plant, has led designers of locomotive boilers to aim at an improvement in combustion; that is, to provide ample grate area and firebox volume in which the combustion processes can be effectively carried out. The effect of this change is striking. At a rate of firing of 80 lb. of coal per square foot of grate per hour, the H6A locomotive showed a boiler efficiency of 50 per cent. The H1s locomotive at the same rate of firing shows a boiler efficiency of 70 per cent. This is mainly due to an increase in the efficiency of combustion, though the use of a superheater and improvements in the proportions of the heating surface have increased slightly the efficiency with which the boiler takes up heat.

The test plant figures show that the H6A boiler had an efficiency of heat absorption of about 80 per cent., and that this has been increased in the case of the H1s to about 86 per cent. These figures vary, but little with the rate of operation. At a rate of firing of 80 lb. of dry coal per square foot of grate surface per hour, the H6A boiler shows in round figures an overall boiler efficiency of 50 per cent., which results from an efficiency of absorption of 80 per cent. and an efficiency of combustion of only 62·5 per cent. That is something like 38 per cent. of all the coal fired escapes up the stack unburned. The modern H1s, at the same rate of firing, shows an overall boiler efficiency of 70 per cent. made up of an efficiency absorption of 86 per cent. and an efficiency of combustion of 81 per cent. This shows a loss of only 19 per cent. of the coal unburned, which is just half that of the older boiler. Part of this is due to the use of a less friable coal, but a very large part is due to the application of the lessons taught by the locomotive testing plant. The use of a firebrick arch, and the provision of a combustion chamber to give space in which the coal can be burned before its escape to the flues have had their influence. Another factor which has been shown by the locomotive tests to require attention is the provision of sufficient air inlets. It is interesting to note that one of the first things shown by the locomotive testing plant was that the H6A boiler was choked by its inability to take sufficient air through the ash pan. An increase in the air openings in the ash pan increased at once the hauling capacity of the locomotive.

Besides pointing the way to improve boiler efficiency, the testing plant has shown how engine efficiency could be bettered. The H6A locomotive of twenty years ago required a steam supply of about 21 lb. per hour for each indicated horse-power. In the H1s this is reduced 25 per cent., and a horse-power is developed with less than 16 lb. of steam per hour.

This gain in efficiency is in part due to the use of superheated steam, but a considerable portion is directly traceable to the information given by the testing plant. In the earlier locomotives with cylinders of the usual proportions, it is necessary in heavy drag freight service at slow speeds to use a long cut-off. When the locomotive testing plant results were used to analyse engine performances, the disadvantage of working continuously at a long cut-off was made obvious. The H1s locomotives were designed to avoid the disadvantages by providing cylinders of sufficient capacity to utilise all of the adhesive weight when working at a cut-off of not longer than 50 per cent. To this end, the cylinder diameter and stroke were made as large as the loading gauge would permit, and the boiler pressure was increased from 205 lb. to 250 lb. per square inch. The most desirable cylinder proportions were determined by trials with a sample locomotive on the testing plant. The results are now embodied in a series of 598 locomotives, which require less than 16 lb. of steam per indicated horse-power per hour.

The locomotive testing plant has also been used to establish for the different locomotive types the tractive power which they can be counted on to give under various conditions of service, and this information has been used in connection with train resistance experiments to establish tonnage ratings over the system.

Altogether the locomotive testing plant in its twenty years of service has shown itself to be a most useful and reliable instrument for the study of locomotive operation.

THE REGULATION OF THE MURRAY RIVER.

IN the past three years or so very definite progress has been made with the works which are being carried out for the regulation of the Murray River. We gave a summary of the scheme planned in ENGINEERING, vol. cx, page 381. Since the date of that article some of the individual works have been brought to completion. It may be interesting to review the arrangement under which these works are being taken in hand, for it will be remembered that three States are directly interested, while the position is complicated by the fact that irrigation and navigation have both had to be embraced in the compromise arrived at. The three States involved are South Australia, Victoria, and New South Wales. Both the latter contribute large volumes to the river, as various rivers flow from either into the Murray, which for a long distance forms their common boundary. Thus, in the upper reaches, although the Murray rises in Victoria and several tributaries flow to it from the south, at Jingellic about 66·4 per cent. of the flow is estimated to come from New South Wales territory. The relative position of the two States is almost exactly reversed at Albury, by which place the volume of the stream is doubled, the Kiewa and Mitta Mitta Rivers, both of Victoria, being mainly responsible for this. In the next stretch a preponderance of contribution is further established in favour of Victoria, the proportion of this State rising to 83·3 per cent. at Torrumbarry, brought about by the influx of such rivers as the Ovens, Broken, Golbourn, and Campaspe. At Mildura the proportion has reverted approximately to the 2:1 ratio, owing to the Murrumbidgee flowing in from New South Wales, this being only partly offset by the contribution of the Loddon from the south. At the South Australian border the proportion is more nearly equal, being about 46 per cent. for Victoria and 54 per cent. for New South Wales, the turning of the scale being due to the confluence of the Darling with the Murray. Of the volume brought down by the Darling a considerable portion, estimated at 64 per cent., comes from Queensland. No tributaries of any moment enter the Murray in South Australian territory, and that State is solely interested in putting to the best possible use, either for navigation or irrigation, the water coming down to it from the upper stretches. The total length of the Murray is over 1,500 miles, of which 1,370 are possible for navigation in good years. The present scheme extends over 900 miles. It may be remarked that the Murray river system drains about 414,000 square miles, of which, however, only about one-third makes effective contribution to the river flow. The rainfall of the area ranges from 40 in. per annum in the Australian Alps, to nil in large tracts of desert. It is

estimated that a total of about 1·5 million acres will ultimately be capable of being put under irrigation when the works are finished.

The independence of South Australia made it possible when she tired of the delay in securing agreement among all parties, for her to proceed on her own account with certain works, since incorporated in the final scheme, and completed. For something like 10 years the joint regulation of the river was seriously considered without real progress being made, but the commission of engineers appointed in 1911 laid the foundation for the present work, by their investigation of the river flow, from which the figures given above are quoted. Their report was published in 1913, and for the first time reconciled gaugings taken by different authorities. The commission consisted of Mr. E. M. de Burgh, M.Inst.C.E. (Chief Engineer New South Wales), Mr. J. S. Dethridge, M.Inst.C.E. (Chief Engineer of Victoria), and Mr. Graham Stewart, M.Inst.C.E. (Chief Engineer of South Australia). Following upon the report, agreement was come to in 1914, and the River Murray Waters Act was passed and came into force in 1917. This Act is administered by a commission consisting of one representative of each of the three States, and one of the Federal Government, the latter acting as chairman. At present the State representatives are Mr. J. S. Dethridge for Victoria, and Mr. J. H. O. Eaton for South Australia, the New South Wales member being Mr. H. H. Dare. The works are designed by "constructing authorities," who are as follows: the Minister for Public Works, with Mr. E. M. de Burgh as Chief Engineer, for New South Wales; for Victoria, the State River and Water Supply Commission, with Mr. Dethridge as Chief Engineer; for South Australia, the Commissioner of Public Works, with Mr. J. G. Stewart as Engineer-in-Chief. Designs are worked out separately, or jointly, as necessary by these engineers and are subject to the approval of the commission in order to maintain co-ordination. The commission's work, however, will not terminate on the completion of the scheme. The body is permanent, having to deal with finance, the collection of tolls, stream gauging, and the distribution of the waters, and has power in bad years to depart from the agreed normal allotment laid down in the Act. The commission also decides upon the precedence and order of construction of the various works decided upon.

As regards the works themselves those in South Australia are to be constructed by that state, while those in the upper stretches will be constructed jointly by New South Wales and Victoria, so far as those on the common boundary are concerned. Either state has the right to construct other works on tributaries below Albury, provided that a specified amount of water is available at the border for S. Australia. There is one exception to the general arrangement as regards construction. Not far from the border of South Australia storage is to be provided in New South Wales for the benefit of the former state. This and the necessary regulating works are being carried out by South Australia. Altogether 35 locks and weirs are provided for in the agreement, of which six will be built in South Australia and of the remainder 20 will be between Echuca and the South Australian border, *i.e.*, on the common boundary between Victoria and New South Wales, and nine in New South Wales on the Murrumbidgee. The Act gave New South Wales the option of regulating either the Murrumbidgee or the Darling. This was exercised in favour of the former river on which, accordingly, nine weirs and locks are to be built between Hay and the junction of this river with the Murray. Owing to precedence having been given to other parts of the scheme these works are not much further advanced than the survey of suitable sites.

The desire of New South Wales to utilise as much water as possible in the upper reaches has led to the largest work of the whole scheme. This is the Hume reservoir on the Mitta Mitta River. It is a joint work being constructed by the states of Victoria and New South Wales. We shall revert to this in due course.

It will be best to commence with the works nearest the coast and work up river. In this order the first works we come to are those at Blanchetown where the William R. Randall lock and weir was put in service in May, 1922. This work is named after the pioneer navigator of the Murray. Between Blanchetown and the mouth of the Murray, a distance of 170 miles, the river is navigable without regulating works. This Blanchetown weir was actually begun in 1915, as already mentioned, before the present Act came into force. It was constructed in accordance with the advice of Colonel E. N. Johnston, of the Corps of Engineers, United States Army, whose services were secured by the State to advise upon the improvement of the lower portion of the river. The work consists mainly of a weir, lock and navigable pass. By the courtesy of Mr. J. G. Stewart, M.Inst. C.E., Engineer-in-Chief to the State of South Australia, we are able to illustrate and give a description of this and the other important works undertaken by that State. The stretch of river involved is illustrated in Fig. 1, below, in which towards the left-hand side, will be found the site of the Blanchetown lock and weir. A plan of this work is given in Fig. 2, from which it will be noticed that on the west side of the river is a lock 56 ft. wide. This has a length of chamber of 270 ft. Next on the right is a navigable pass 199 ft. in length, following which is a permanent weir structure of fourteen sluices formed of concrete piers fitted with stop logs. Figs. 13 and 14, on Plate XXIV, give views of the complete work from the down stream side.

Fig. 1.

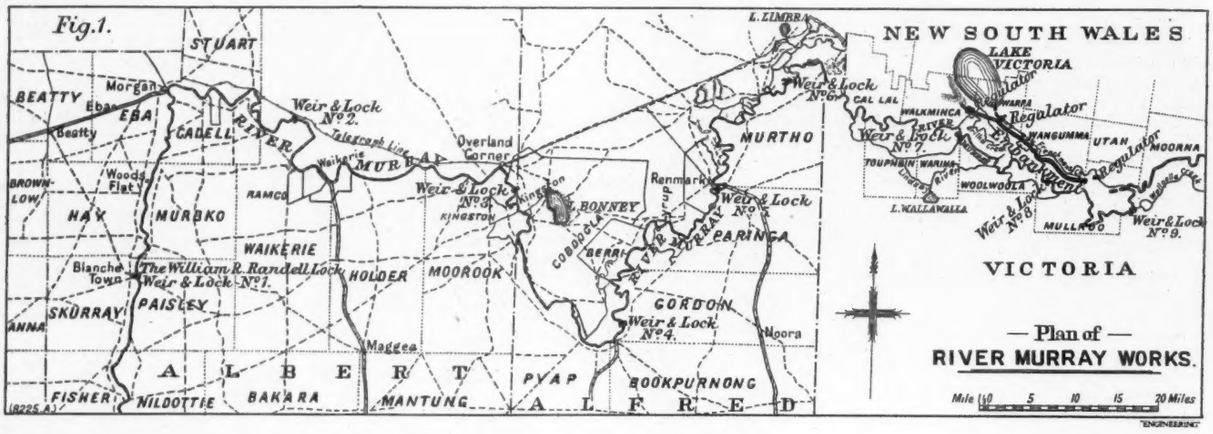
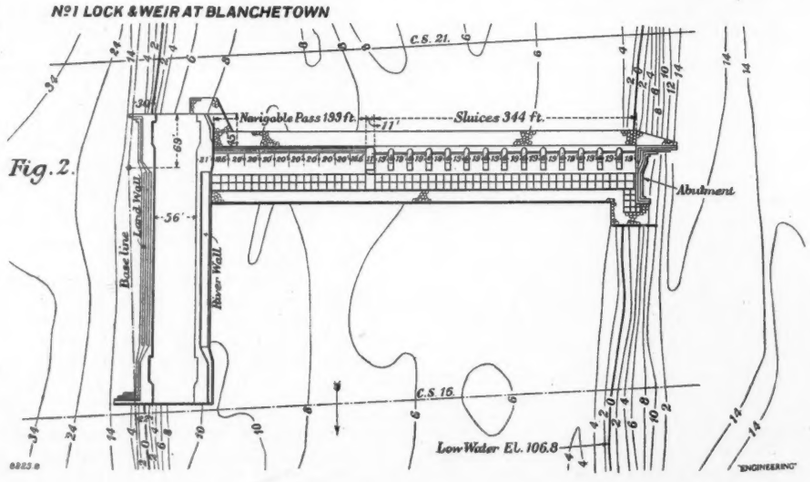


Fig. 2.



In the report by Colonel (then Captain) Johnston the question of the size of the vessels plying on the river was considered and two alternatives were put forward. The width in both cases was suggested as 56 ft., but the length of chamber was 275 ft. in one case as compared with 170 ft. in the other. In the South Australian length of the river the larger structure has been decided upon for all the works to be built, but higher up the river the shorter length has been deemed sufficient. The greater length admits into the lock a towing steamer and two barges, tows being common practice on this part of the river. The lock is shown on the left hand in Fig. 13, while several views are given of it during construction in Figs. 3 and 4, on page 373, 12 on Plate XXIV and Figs. 15 and 16, on Plate XXV.

The lock structure has an overall length of 378ft. The maximum lift is 10·7 ft. At the site, rock was found not far below the ground surface, but dipping towards the channel. The land wall of the chamber is founded direct on this rock, but the floor and the river wall are carried on piles driven down to rock. At the outer edge of the river wall is a line of

sheet piling. This is carried also across the lock at each end of the chamber floor. The piles taking the load of the river wall are spaced at 3 ft. 6 in. centres. Those supporting the floor are at 4 ft. centres. A view of the piling for the lock is shown in Fig. 15. The walls are mass concrete, the river wall being 18 ft. thick at the base battered to 6 ft. thick at the top, and the land wall 16 ft. thick at the base and stepped to 5 ft. at the top. The floor is of reinforced concrete 3 ft. thick, the reinforcement being of 1¼-in. rods spaced 12 in. cr. to cr., and extending across the floor, and 8 in. under each side

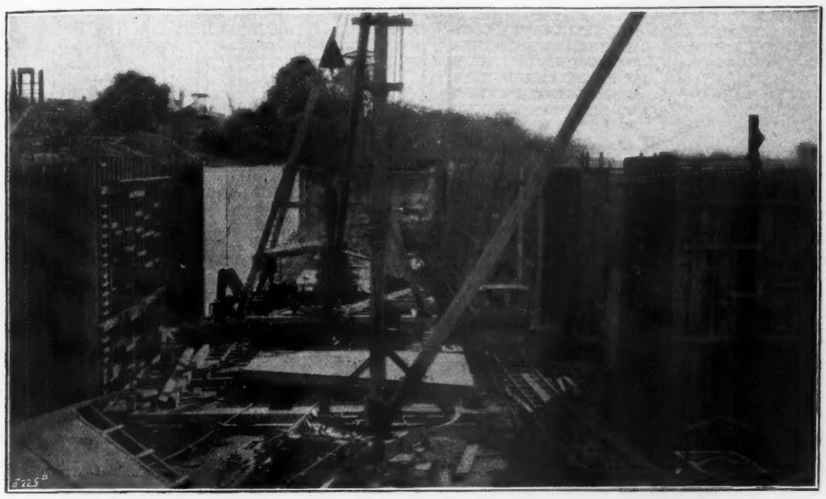


FIG. 3. INTERIOR OF LOCK DURING CONSTRUCTION.

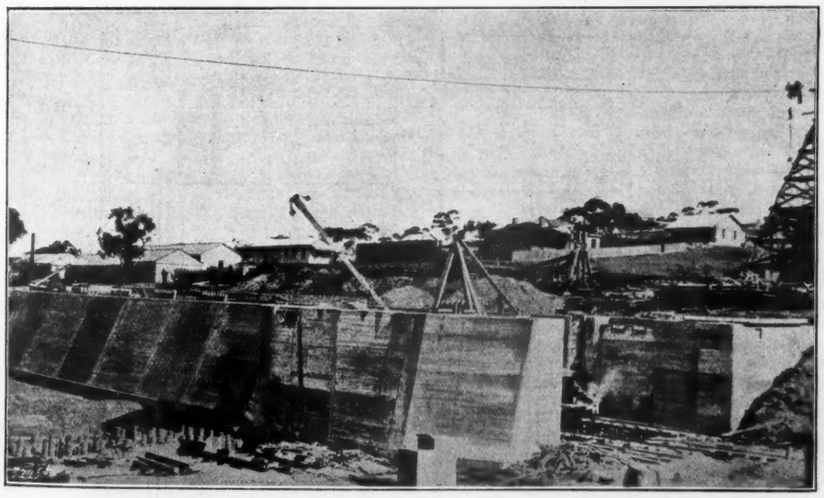


FIG. 4. COMPLETED LOCK WALLS AND PILING FOR NAVIGABLE PASS FOUNDATIONS.

wall for the length between the upper and lower gate quoins. Below the lock floor are six 12-in. drain pipes laid in 2-in. crushed stone surrounded by ¼-in. screenings. At parts where large culverts run through the side walls, reinforcing bars are inserted in the mass concrete outside the culvert, the bars running in an upward direction parallel with the back of the wall. These bars are ¾ in. in diameter and are spaced 12 in. cr. to cr. The side wall culverts have a maximum cross section of 7 ft. 9 in. high by 5 ft. wide. On each side, outside the upper gates, are three sluice gate openings, the water entering the chamber by five side openings on each side distributed over a length of 99 ft. At the lower end on each side three sluices connect with a culvert, having a single discharge beyond the gate.

We do not propose to enter into further details of construction in connection with this lock for reasons which will be apparent later. It will suffice to say that the work was constructed in the dry, behind a cofferdam and that the walls were constructed in monolith lengths of 40 ft. These will be recognised in several of our illustrations. For instance, in Fig. 12, on the right, may be seen the shuttering in course of preparation. Fig. 16 shows some of the forms further advanced, while Fig. 3 shows the work well forward. The view in Fig. 4 is at a later stage and indicates clearly the block construction adopted.

The remainder of the work consists of the weir foundation extending across the river, wing wall and abutment on the East bank, and the sluice piers. The raft or platform of this work consists of a thickness of 5 ft. of concrete of from 33 to 35 ft. long in the up and down stream direction. This is supported throughout by piles, spaced 3 ft. 6 in. apart for the sluice section. All were driven through sand to underlying rock, about 20 ft. below low water. A line of cut-off timber sheet piling with grouted joints extends across the river on the up stream edge. The pile heads were cut off to extend into the concrete from 1 ft. 6 in. to 2 ft., according to position. The piling is best shown in Figs. 5, 6, 8 and 9 on pages 374 and 375. The two first show the sluice part of the weir; the two last the scheme adopted at the navigable pass. The platform or raft is reinforced over the navigable pass, and at the piers for the sluices. The raft is protected on the up-stream side by a clay blanket 2 ft. 6 in. thick covered with rip-rap laid on crushed material. This extends for the sluice section for 20 ft., and for the navigable pass for 50 ft. up stream. On the down-stream side protection is afforded by timber cribbing 12 ft. 6 in. deep, of 10 in. by 10 in. jarrah, filled with rip-rap. From the bottom of the trench in which the cribs are placed the floor is sloped at about 1 : 2 to the normal bottom of the channel, and the excavation thus formed filled with large stones placed by derricks. The cribs extend 20 ft. in the up and down stream direction, and the rock filling and further rip-rap protection extends for an additional 50 ft. down stream at the navigable pass, but for only 20 ft. at the sluice section. These details may be seen in Figs. 9 and 10, and 5 and 6.

The sluices extend, as shown, in Fig. 2, over a length of 344 ft., terminating at one end with the east abutment wall, and at the other end by a special pier 11 ft. wide, separating the sluice section from the navigable pass. The sluices are placed as far away from the lock as possible, in order to avoid risk by possible scour. The 14 sluice openings are of 19 ft. clear width, the intervening piers being 6 ft. wide. The normal piers are shown in the plan, Fig. 7, and in the elevation, Fig. 5, page 374. They are of mass concrete, 19 ft. at the top in the up and down stream direction, and are tied to the raft by 26 1-in. bars about 2 ft. apart, extending to well below the horizontal reinforcement inserted in the raft under the piers, and running in a direction across the stream. Vertical grooves set back 3 ft. 6 in. from the up-stream face, and 15 in. wide by 17 in. deep, are provided in the piers to take the stop logs. The latter are 12 in. by 12 in. jarrah balks for the lower logs, and 10 in. by 10 in. for the upper. The ends of the logs are fitted with pins, and the logs are handled by hooks and lowered down the pier recesses. Travelling hand cranes are used for this purpose. Along the top of the piers runs a wide gangway, as well as a track for the hand cranes.

The end pier in mid-stream is illustrated in Fig. 6, and the plan, Fig. 7. The chief features of this will be seen to be the additional support given to the toe, where the 5-ft. raft is run out for 20 ft. down stream, the extension being carried on a single row of piles spaced 4 ft. apart. Tongued and grooved piling is also at this point carried practically round the pier, as shown in Fig. 7.

The navigable pass is intended to provide a clear channel outside the lock, at times of high flood. This period occurs once a year, and ample warning is received of it. At such times the sluices would be open and the water flowing has sufficient volume and depth for navigation without any regulation. The weir is fully opened when the flow of the river reaches 6,000 cusecs. The type of weir recommended by Col. Johnston, and adopted, was the Boulé pattern, and is illustrated in Figs. 8 to 10, page 375, while it may be seen in use in Fig. 18, on Plate XXV, and in the general views, Figs. 13 and 14, on Plate XXIV. This form of weir is considered to be very economical, easily worked and better for the maintenance of a clear waterway than any type employing needles or paddles.

The Boulé weir consists of a series of bents or trestles, hinged at the base and capable of being let down flat on the weir floor when the river is in flood and the pass is open for navigation. When in the upright position the bents are connected at the top by joists, by which vertical supports are held in position. The flow is held up by panels carried by these verticals. The bents are centred 20 ft. apart, and they are between 18 and 19 ft. high, so that each folds down into a bay without fouling the next. Along the top run two 15-in. by 60-lb. joists. The more upstream of these support the verticals, which are 18 in. by 60-lb. joists, spaced 3 ft. 4 in. apart. A drawing is given of the up-stream hinge of the bent, and of the sill arrangements in Fig. 11. The toes of the vertical joists rest in a groove lined with a Z bar backed by a small joist and supported at intervals by vertical joists buried to a depth of 5 ft. in the concrete raft. Bosses on the Z bar ensure the correct spacing of the vertical joists.

The panels, or flash boards, slide on the up-stream faces of the verticals. They are fitted on the back

with projecting angle irons which serve to guide them correctly. The full height of 16 ft. 5 in. of impounded water above the sill, is held up by vertical series of nine panels, of which the four lowest are 3 ft. 2 in. deep, the next two 1 ft. 7 in. deep and the three highest 6⅝ in. deep. All are 3 ft. 2½ in. wide, and, with the exception of the three highest are protected at the sides by angle irons, each being fitted with a handle. The deep panels are of 2½ in. New South Wales tallow wood. The intermediate size are of the same timber, 1¾ in. thick, while the 6⅝-in. panels are 1-in. Californian redwood. They are handled by hooked lifters and pushers, from a hand crane on the gangway laid on the joists joining the bents at the top, but at flood time the upper movable parts and the hinged bents are handled by a derrick boat.

It will be noted from Fig. 9 that the up-stream side of the raft is much deeper at the navigable pass than the 5-ft. thickness given previously. The provision of additional 5 ft. thickness is made in order to accommodate substantial anchorage of crossed joists to hold down the up-stream hinge pin at the foot of the bents. The joists are 10 in. by 25 lb., up and down stream, laid on 15-in. by 42-lb. lengths across stream.

The whole structure, as already stated, has a length over abutments of 660 ft. Construction was carried out in two cofferdams, cutting off half the width of the river at a time. The cofferdams were made of two rows of sheet piling 16 ft. apart, the outer row being of interlocking steel piling and the inner of timber, braced together by tie rods, the space between being filled with earth, by a dredger working in the enclosed space. When the dredger's work was completed it was floated out, the gap closed and the water subsequently pumped out. The tops of the cofferdams were 13 ft. above low water and they remained very dry while in use. The amount of pumping normally was very small, although at some stages the head above the foundation trenches was sometimes as much as 24 ft. During the course of the undertaking, which was commenced in 1915, an unusual sequence of exceptionally high floods submerged the work completely on several occasions for considerable periods, greatly delaying progress on it, this being also rendered difficult by conditions arising out of the war. The work was carried out departmentally by day labour. Concrete, &c., was delivered by aerial cableway.

(To be continued.)

BRITISH TRADE WITH THE WEST INDIAN COLONIES.

THE chief industries of the British West Indies are agricultural, and consequently the only engineering trade is in power plant, locomotives and railway equipment, motor vehicles and machinery for repairs to keep these in running condition, for use in agriculture, constructional work and for general purposes. This is usually imported and mainly from the United States or the British Isles. There is, however, another feature of the trade of these colonies which is of engineering interest, that is the provision of adequate cold-storage accommodation in the vessels carrying tropical fruits from the islands to the United Kingdom. It may be said that with some few exceptions the transport facilities, both internal and inter-colonial, are very defective, but the immediate need is for improvement in the provision to deal with overseas trade. While the present conditions of sea transport persist it must be recognised that the United States will continue to do a very large part of the trade with the British West Indies. A recently-issued Report on the Economic and Financial Conditions in the British West Indies, prepared by Mr. J. L. Wilson Goode, for the Department of Overseas Trade, enables an estimate to be made of the prevailing conditions in the staple industries, and affords an indication of the possible demands for British goods and the requirements which must be met to obtain an increased share in the markets.

There are many natural products of these Colonies which are of great significance to engineers. Balata, for instance, which is the coagulated latex of the balata tree, is in great demand for use in the manufacture of belting and cables. The trees are scattered all over British Guiana, which is also covered by the report, but in some areas this Colony such as the upper valley of the Berbice river, the Rupununi district, and the forest regions above Kaieteur Falls, the growth is very extensive. The principal balata concessions are very inaccessible, and river craft is the usual means of transport to Georgetown. Indeed, there are certain locations where balata is grown, which are so remote that they can only be reached in river craft after from 15 to 20 days' hard pulling against the stream.

During 1923, owing to adverse financial conditions, it was not possible to open up any new areas for the winning of petroleum, and the only extensions that were made were confined to proven fields. Crude oil to the extent of 106,780,000 gallons was obtained and represented an excess of 21,000,000 gallons over the production of the

THE REGULATION OF THE MURRAY RIVER.

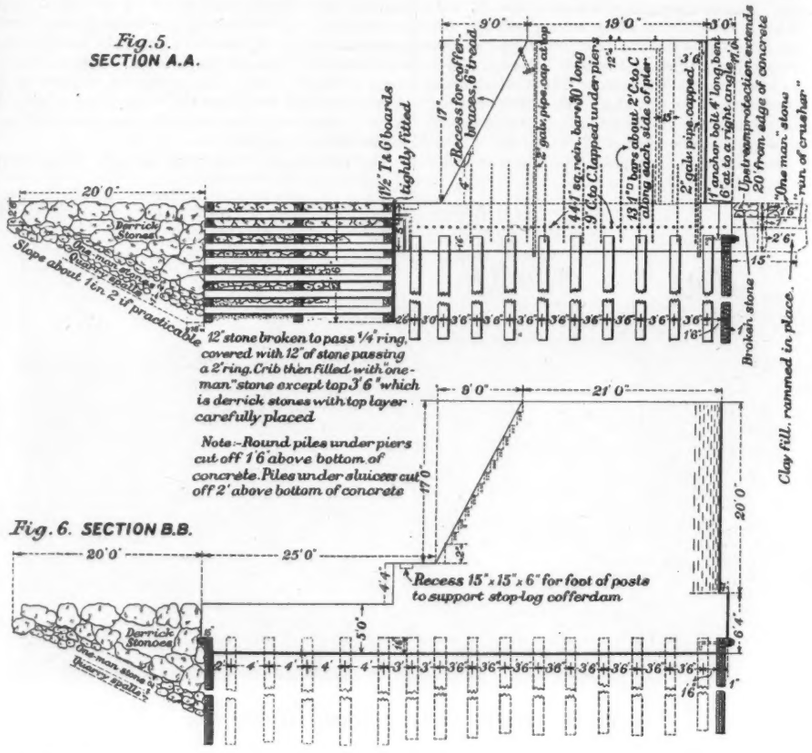
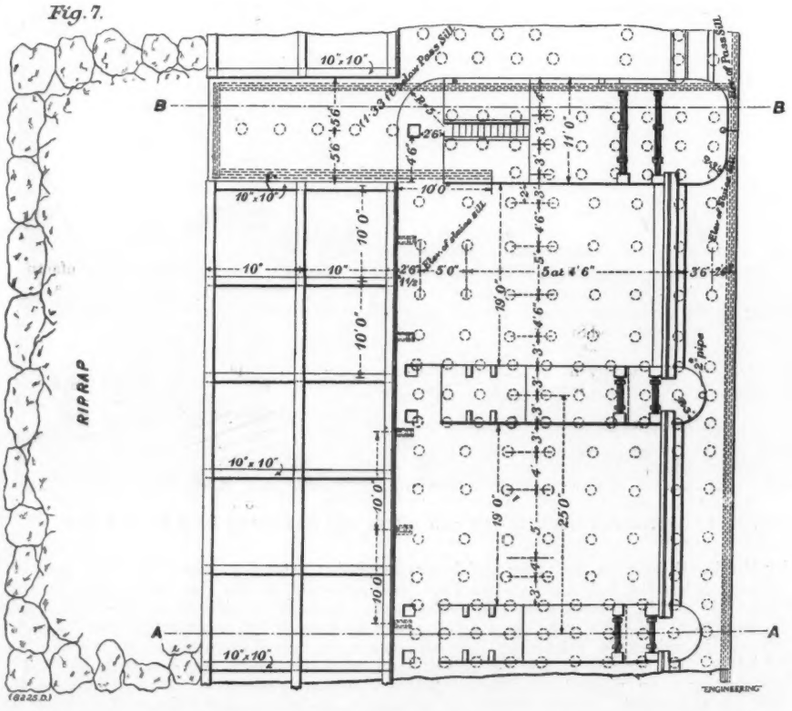


Fig. 5.
SECTION A.A.
Derrick Stones
One man stone
Quarry spalls
Slope about 1 in. 2 if practicable
12" stone broken to pass 1/4" ring, covered with 12" of stone passing a 2" ring. Crib then filled with "one-man" stone except top 3' 6" which is derrick stones with top layer carefully placed
Broken stone
Clay fill, rammed in place.
Note:-Round piles under piers cut off 1' 6" above bottom of concrete. Piles under sluices cut off 2' above bottom of concrete
Fig. 6. SECTION B.B.
Recess 15" x 15" x 6" for foot of posts to support stop-log cofferdam
Derrick Stones
One man stone
Quarry spalls

Fig. 7.



THE REGULATION OF THE MURRAY RIVER; NAVIGABLE PASS AT BLANCHETOWN.

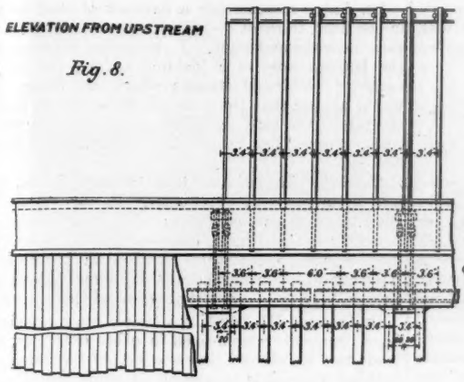


Fig. 8.

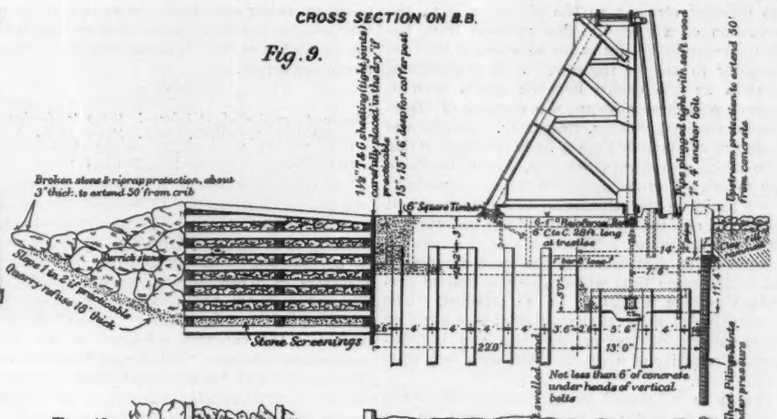

CROSS SECTION ON B.B.
Broken stone & riprap protection, about 3' thick, to extend 50' from crib
Stone Screenings
Not less than 6" of concrete under heads of vertical bolts

Fig. 9.

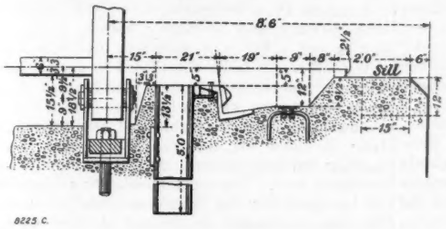


Fig. 11.

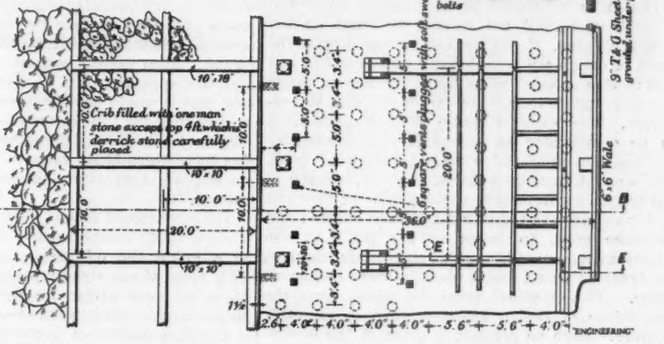

Crib filled with one man stone except top 4 ft. which derrick stone carefully placed
6 Square vents plugged with soft wood
6' Reinforced Beam
6 Cls C. 28 ft. long at trestles
6.6' Wale
3' T & G Sheet Piling, Wide grooved, under pressure
"ENGINEERING"

Fig. 10.

previous year. Altogether, some 85,000,000 gallons were exported as against 56,000,000 in 1922. Arrangements exist under which regular shipments of oil fuel are made for the British Navy, but, in addition, large quantities are sent to private concerns in the United Kingdom and the United States of America. Another natural product of these Colonies is pitch from the Trinidad lake. The resources are not, of course, inexhaustible, but in the forty years during which export has been undertaken, the level of the lake has only fallen about 13 ft. Prior to shipment a refining process is carried out in stills, principally for the removal of much of the water content. Of the output of dried asphalte in 1923, amounting to 129,363 metric tons, 56,712 metric tons were sent to the United States and 44,913 metric tons to the United Kingdom. In addition, the United States took the entire export of 41,838 metric tons of crude asphalt.

The demand for machinery in the British West Indies, other than that for the manufacture of sugar and for the oil wells, is but small, and any special plant which is required by the Government for purposes of development of their territories is dealt with through the Crown Agents for the Colonies in London. Important developments are being made in the sugar industry, and it is highly probable that there will be an increased demand for sugar machinery. In plant of this type, there is a marked preference for the products of British concerns. In the oilfields another situation exists, for most of the machinery was obtained from the United States during the European War. There is, however, a growing demand for wire ropes of British manufacture and also for casing, and in both cases the products of British firms are giving great satisfaction. Tinplate is also in demand for the manufacture of containers for petrol and other oils which are made in the Colonies. America has most of the trade in pipe lines, drums, belting, engine packing and jointing materials, but the products of British firms in these lines are in increasing demand. It has been estimated that the total value of the general stores held by the Trinidad oil companies amounts to no less than one million pounds sterling, and of these some 80 per cent. are of American origin. In general agricultural implements and machinery British manufactures are preferred in the West Indies, and there is a good market for the smaller items of agricultural equipment. German efforts to enter this field have been made but not with any great amount of success. In wire and wire goods the trade is almost entirely British, because of the large preferential tariff in favour of goods from the United Kingdom and Canada. In oil lamps efforts have been made to secure a market for British products, but it is thought that progress must be slow until the producers supply lamp glasses and shades and so turn out a complete article. German competition in cutlery exists, and for the cheaper classes is extending at a rapid rate.

Although the British motor-car manufacturers have made determined efforts to secure a larger share of the market than they have at present, the high initial cost of most British cars has for long been a serious deterrent to progress. Cheap American cars are plentiful and are well known in the countries concerned, while the efficient system of dealing with spare parts is of great benefit to the users. Roads are being improved and extended to make them fit for motor traction, especially in Jamaica and Trinidad. For the present, the demand is for low and medium grade cars at from 200*l.* to 400*l.*, and the requirements are best met with a light car capable of running over the rough country. One reason for the strong hold that American electrical manufacturers have in the British West Indies is that, at the time the supply undertaking started operations, American material was much cheaper than any other. American standards thus came to be adopted and the trade has been continued. Electric light and tramway rules have since then been modified to permit the use of British fittings, which comply with the Regulations for the Electrical Equipment of Buildings of the Institution of Electrical Engineers. Before this change of outlook, the standards were those of the National Board of Underwriters of America and this acted as a restraint to British trade. A warning is given in Mr. Wilson Goode's report to British manufacturers, that they must prosecute inquiries carefully before appointing resident agents, as there are many firms with neither means nor commercial knowledge, nor even honesty, who endeavour to obtain such appointments. For goods in which there is but a small local demand, agencies are not accepted by the reputable concerns, and manufacturers are advised to send periodical catalogues and price lists direct to the retail stores.

In Jamaica the Kingston General Commissioners have been authorised to spend 428,000*l.* on an electricity supply scheme, including public lighting and a new sewerage scheme. A dam, estimated to cost 198,000*l.*, has been sanctioned for construction at Hermitage, in connection with a water storage project. Although tenders were received for this from many firms in Canada and the United States, the work has been given to one of the two English concerns that submitted offers. Water supply schemes are also under consideration for Trinidad, Tobago and British Guiana.

LITERATURE.

Electrical Design of Overhead Power Transmission Lines. By W. T. TAYLOR, M.Inst.C.E., M.I.E.E., and R. E. NEALE, B.Sc., A.M.I.E.E. London: Chapman and Hall, Limited. [Price 21*s.* net.]

THE sub-title of this book announces it to be a "Systematic Treatment of Technical and Commercial Factors; with special reference to Pressures up to 60,000 volts and Distances up to 100 miles." The contents are limited to these special references. We would suggest without any disparagement that these limitations in the scope of the work might have been made apparent when the main title was selected. It is quite true that for these limits none but the simplest assumptions are ordinarily involved in the calculations. The complete investigation of the effects of distributed capacity and self-inductance is justified only when longer distances are involved, and consequently much higher transmission voltages become essential to economical working.

Within the chosen limits the authors give a singularly complete account of practical transmission line design, and engineers called upon for the electrical design of overhead lines in this country

will find the methods set out in these pages admirably suited to their needs. The treatment is definitely practical and commercial, and for the most part directed straight to the objective, viz., the production of a design. The problem from the electrical standpoint lies in the selection of the best conductor to use for the line. Such independent variables as the choice between direct current, single or polyphase systems, the distance of transmission, received voltage, frequency, material and spacing of conductors form a basis of design giving a line having a specified power loss. Again, the design may go forward by specifying the voltage regulation; or yet again by the stipulation of a line such that the annual charges on this part of the undertaking shall be a minimum. The best size of conductor is found to be that which is the most economical and at the same time will enable the desired percentage voltage regulation to be attained. The practical limits of the above variables together with considerations of temperature rise and current-carrying capacity of wires are dealt with very fully in Chapter 5.

Design as influenced by mechanical matters is touched upon, but not treated at length in the present volume. Power loss and voltage drop as the bases of design are accorded full consideration, and this section gains in value by the numerous charts and appropriate calculations from the data so presented. The practical nature of these diagrams is to be commended as indeed is the consistently practical and quantitative method of the whole book. Space might have been saved, however, if much of the standard information about conductor sizes and materials given in Chapter 2 had been omitted and reference made to issues of the B.E.S.A., the American Bureau of Standards and certain standard publications which find a place in every engineer's office. The electrical principles which form the foundation of design are developed in an early chapter. Here an account is given of the several systems of transmission and their circuit relations. Vector diagrams are freely used and the explanations of the simple series and parallel connection of the several types of circuit, power factor, regulation and other standard alternating current diagrams are sufficient for the purpose. Exception must be taken to the statement on page 13, where the expression $\sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$ is said to be "clearly the effective resistance." It is clearly not the effective resistance, but as the next line tells us, it is "generally called the impedance."

Criticism may perhaps be directed to the method of arriving at the relative weight of conductors for the several systems under different assumed conditions of transmission. Only in a low-tension distribution scheme, when comparing direct and alternating systems, should the virtual value of the alternating voltage be taken as the equivalent of the steady direct pressure. Here the basis of comparison must be the same pressure at the consumer's terminals; direct in the case of the D.C. and virtual for the A.C. In a transmission line using overhead wires the expense and trouble associated with insulation involve not the virtual value of the voltage but the maximum value of the stress to the earth or neutral. For a sine-wave form this maximum stress is 1·414 times the virtual or R.M.S. value. Similarly with cables, insulation has to be provided with a view to the maximum value of the potential difference between the cable cores. If the direct-current system of transmission be compared with the three phase on the basis of the same amount of power transmitted with the same percentage line loss and with the same maximum value of potential we have the following results assuming balanced loads, unity power factor and a sine-wave of voltage. For overhead conductors with same maximum voltage to earth, the middle or neutral point of both systems being earthed, the ratio of total weight of conductor for direct current to weight for three phase is as 1 to 2. If the basis of comparison be the same maximum potential between conductors this ratio becomes 1 to 1·5. The ratios are in favour of the direct-current transmission line compared with the three-phase, and if comparison is necessary, it should, in our opinion, be carried out as indicated and not by taking the virtual value of the alternating voltage as the authors have done. In conclusion, even a cursory inspection will indicate the great amount of labour expended in compiling the tables and charts drawn to save the user's time and the practical nature of these together with the excellence of their reproduction carry their own recommendation.

Simple Examples of Reinforced Concrete Design. By OSCAR FABER, O.B.E., D.Sc., M.Inst.C.E., A.C.G.I., Hon. A.R.I.B.A. London: Oxford University Press. (Mr. Humphrey Milford.) [Price 5*s*.]

A SERIES of examples of designs in reinforced concrete, such as we now have under review is very instructive to those studying the subject or desirous of obtaining information upon the methods to be adopted in calculating the sizes of various members of a structure and their reinforcement. The value of Dr. Faber's book, when considered as a unit, is unfortunately somewhat lessened owing to the constant reference to the author's companion volumes "Reinforced Concrete Simply Explained" and "Reinforced Concrete Design," the reader being frequently referred to tables and diagrams published in these two books, without which certain factors in the calculations cannot be ascertained. After careful perusal of the six examples and the appendix, one is forced to the conclusion that it would have been better had Dr. Faber waited until the time arrived for the issue of a new edition of "Reinforced Concrete Simply Explained" and then added to its value by the inclusion of the worked-out examples contained in the present volume.

The examples of design, dealt with by the author, cover a fairly comprehensive field, and with these as a guide the designer could deal adequately with most of the structures in reinforced concrete likely to come within his purview, provided the author's other publications were available.

The first example is a circular tank, 10 ft. diameter, with 10 ft. depth of water, resting on the ground and without earth backings. In this example Dr. Faber follows the customary practice of allowing no tensile resistance for the concrete, and adopts the low safe stress of 8,000 lb. per square inch as the resistance of the circumferential reinforcement. To ensure watertightness, he recommends that the tensile stress in the concrete shall not exceed 60 lb. per square inch for 1 : 1½ : 3 concrete. He provides rebated construction points, as a further precaution against possible leakage, and gives an empirical formula for the thickness of wall at various depths. With cement, as manufactured at the present time, the limit of 60 lb. per square inch for the tension in the concrete appears somewhat low, but its application in the case of a tank is immaterial, since the thickness of the walls is generally governed by other considerations—a higher allowance would be justifiable in the case of pipes.

It might be pointed out, that if the steel is stressed to 8,000 lb. per square inch, and if the ratio of the coefficients of elasticity of steel and concrete in tension is assumed as high as 20, the concrete will be stressed to 400 lb. per square inch. In actual fact the stresses must be shared by the steel and concrete in the proportion of their elastic coefficients, and in the case under consideration the stress on the steel will be about 760 lb. per square inch, while that in the concrete will be about 38 lb. per square inch.

Although it is contrary to the usual practice, there appears no adequate reason why, in the case of structures to resist fluid pressure, the concrete should not be considered as resisting some tensile stress; as it must do so in reality, since it suffers a tensile strain of some intensity before cracking. It would seem that the correct way to design a pipe or similar structure under internal fluid pressure, would be to allow a tensile stress in the concrete of one-third or one-fourth of the ultimate tensile resistance of test briquettes at 28 days, composed of the proportions of cement and sand in the concrete, and to proportion the circumferential reinforcement, so that its resistance will not exceed, say, twenty times the working stress on the concrete, with a proviso that under any circumstances say, 0·20 sq. in. sectional area of steel, must be employed in each foot of earth. Designed in this manner, such a structure must function in close approximation as calculated.

Dr. Faber recommends a network of steel rods in the floor, to resist accidental stresses, and places these near the underside. If the ground supporting the bottom were of a yielding nature, the only cause of accidental stresses which can occur, it would appear that the rods should be placed near the top of the slab, except when approaching the sides, where they would be required near the bottom.

Example II is a similar tank to Example No. 1, but square instead of circular. In this example Dr. Faber deals adequately with the bending moments at the corners, but somewhat empirically with regard to the direct tension in the sides, referring to his former book "Reinforced Concrete Design," for the accurate treatment of this feature.

In Example III, covering a simple beam and slab floor, frequent reference as in other examples, is made to "Reinforced Concrete Simply Explained," without which it is impossible to apply the calculations to other examples of the same kind. The author appears to have either dimensioned the spacing of the inclined bars wrongly, in Fig. 7, or used wrong values for these dimensions in his calculations.

Example IV, a warehouse floor 100 ft. by 100 ft., with primary and secondary beams, having two stories and a flat roof, is a very useful one, as it covers all points to be considered in the design of a simple warehouse building. The spacing of the secondary beams is somewhat large (8 ft. 4 in.). It would have been preferable had assumed weights been included for the various members before making the calculations, instead of assuming an inclusive load. The recommendation of ½-in. rods 28 in. apart for the transverse reinforcement of the slabs is unusual, the general practice being to use smaller bars with closer spacing. Dr. Faber takes into consideration the bending moments in the columns due to the action of the supported beams, but shows that these are only material in the case of wall columns.

Again, in this example the author has either dimensioned the spacing of the inclined bars wrongly, in Fig. 9, or used the wrong values in the calculations on page 33.

The fifth example is a retaining wall 20 ft. high with the bearing slab projecting in front. This is an unusual and uneconomical design, and it is somewhat surprising that the author should have selected this type for treatment.

It would have been clearer if Dr. Faber had adopted different symbols for the depth of the earth backing and the thickness of the wall. The value for the pressure per square foot on the back of the wall is given as $30h$, without any explanation as to how this factor is obtained. It is the correct value for a soil weighing 120 lb. per cubic foot and having an angle of repose of 37 deg., calculated by Rankine's formula $wh\frac{1-\sin\phi}{1+\sin\phi}$. This formula should have been given to permit of the treatment being used for the design of similar structures under different conditions.

The bald statement, at the bottom of page 63, that, since the centres of gravity of the front wall and the base with its earth covering, are respectively 9 and 81 in. from B, the centre of gravity of the whole is 45 in. from B, should have been dealt with in more detail.

The stability of the wall is somewhat doubtful, since the maximum pressure on the foundation is, according to the author, very nearly 2 tons per square foot just before the wall overturns, no factor of safety against overturning being mentioned.

The problem of stability might well have been dealt with on the following lines:—

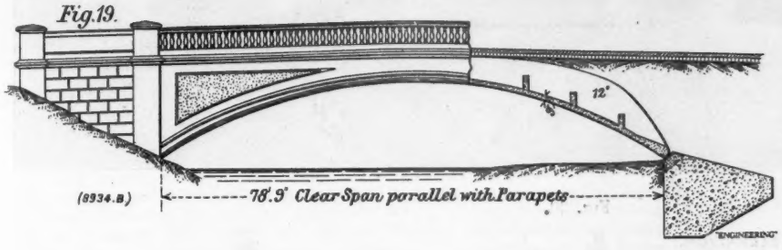
The overturning moment is $330 \times 21{\cdot}5 \times \frac{21{\cdot}5}{3}$ = 50,847 ft.-lb.

The moment of stability about the toe is 8,670 × (11 ft. − 3 ft. 9 in.) = 62,858 ft.-lb., giving a factor of safety of 1·23, and this with an assumed angle of repose of 37 deg. Some authorities would consider this insufficient, since the stability against

ROAD BRIDGE OVER THE RIVER CART, GLASGOW.

FIG. 18.

Fig.19.



overturning is independent of the resistance of the supporting soil.

Fuller explanation should have been given for the statement, on page 66, that the safe horizontal pressure of the heel against the earth is $p = 480h$. This value is correct for soil weighing 120 lb. per cubic foot and having an angle of repose of 37 deg., according to the formulæ $p = wh \frac{1 + \sin \phi}{1 - \sin \phi}$. It is difficult to understand why the author does not give this formula. The toe would resist sliding more effectively if placed under the front-wall slab.

Example VI is a square water tower 16 ft. by 16 ft. by 8 ft. deep on four inclined columns, the bottom of the tank being 50 ft. above the foundations of the columns. This example is fully dealt with, but no reference is made to the footings of the columns, which appear somewhat inadequate from the sketch (Fig. 18).

The treatment of the racking strains due to the action of wind is fully considered, but would have been more valuable had a tower supported on a greater number than four columns been selected.

The appendix to the volume, dealing with moments in columns due to the action of supported beams, is interesting and instructive, but here, as elsewhere, the value of the treatment is diminished by the frequent references to "Reinforced Concrete Simply Explained."

Economics of Iron and Steel. By H. J. SKELTON. Second Edition enlarged and illustrated. London: Stevens and Sons, Limited. [Price 1*l.* 0*s.* 0*d.* net.]

MANY engineers, merchants, and others use iron and steel without much knowledge of how these materials are made, or even of all the forms, other than those they have been in the habit of handling, in which they are produced. For such persons Mr. Skelton produced the first edition of this work over thirty years ago, and the present edition, much larger and more comprehensive in every respect, is intended also for their use. It is in no sense a treatise or a textbook on the manufacture of iron and steel, but a compendium of so much of the practice both of making, specifying, and dealing in the heavy iron and steel trades as persons engaged in handling those materials require to know if they have not been trained in their manufacture and yet wish to make intelligent use of the various products the trades include. The author has been associated with iron and steel works all his life, and for many years has had to use his wide experience, not only for the purposes of his own business as a contractor, but also for those of important users at home and abroad for whom his firm has acted as buyers. He has also taken a prominent part in the co-operative activities of the trades during the whole of the present century, and among other public posts now holds the position of Chairman of the Committee of Management of the London Iron and Steel Exchange. He has, accordingly, high credentials of competence for producing a work with the objects here in view and it may be said without reservation that the book should be of constant value to all the classes of persons for whose use it is written. The value will be the greater because, with the help of Mr. L. P. Salter, the author has provided an unusually full index.

The book is divided primarily according to materials, with subdivisions according to products, and, as a rule, under each heading the whole of the available information is given, from the materials and processes of manufacture to the particulars of trade practices. Broadly speaking, about a third of the work is devoted to this treatment of ores and cast and wrought-iron, and a half to steel and steel products. The remainder deals with general trade practices, conventions and nomenclature, tables of usual sizes, extras, &c., and a vocabulary of scientific and technical terms. The descriptions of processes are always clear and yet non-technical, and, while avoiding points of doubt and difficulty, give a sufficient account of the subject to enable the reader to have a general understanding of the nature of the several processes and of their respective scopes. In the variety of products and the trade details of the information in regard to them the book is particularly strong. It includes, for instance, not only chapters on rails and fastenings, railway rolling-stock material, plates and sheets, tubes and pipes, and hoops and strips, but also such subjects as tinplates, galvanised sheets, and all sorts of commercial scrap. A long chapter describes the various types of melting furnaces, and those that follow it, dealing with the several stages of partly manufactured products through which steel passes, not only give useful information on what defects may be acquired at each stage, but tell more than most engineers know of the various methods by which the finished products are reached, and the purposes for which they are respectively desirable. Similarly, the account of pig-iron, besides a description of the various types of furnace, gives useful particulars of the characteristics of the principal ores and irons; and both in pig and in wrought-iron a careful account is given of the commercial practices by which trade in them is regulated. The technical specification and control of wrought-iron chain and cable is described in some detail, and in chapters on testing wrought-iron, cast-iron, and steel the information given is what is wanted from the point of view of readers who are concerned with the commercial application of such tests and the practical use of materials that have been subjected to them.

A characteristic feature of the book is the considerable amount of information given about the requirements and practices, not only of different authorities, but of different countries. This is seen in the treatment of most topics; examples, taken almost at random, that show it particularly well are the excellent chapters on carbon and other special steels and on tolerances. The latter is concerned, of course, not with dimensions of tooled parts, but with sizes, weights, &c., of the semi-finished and finished products of steel works and mills, which are not so generally known by engineers; and the information here collected should be found very convenient. The work is well and sufficiently illustrated; and though the author gives little more attention to technical differences of processes and practices than is necessary for the purposes of non-metallurgical readers, he deals in considerable and well-informed detail with the trade aspects of the various divergences of practice that he describes. It may be remembered that he was among the earliest in this country to urge publicly the importance of reducing the number of varieties of stock sections by appropriate standardisation, and the present work shows the considerable improvement that has been brought about in this respect since the first edition was published.

BRIDGE RECONSTRUCTION WORK OF THE MINISTRY OF TRANSPORT. No. II.

IN our issue of February 27 last, page 250, we outlined the general policy of the Ministry of Transport in regard to the bridge reconstructions necessitated by the phenomenal growth of road traffic. We also described in detail the widening and strengthening of the famous Waterloo Bridge at Bettws-y-Coed. This is an arch bridge rigid at the springings, a type which has given remarkable service under heavy concentrated loads, as was evidenced by the behaviour under "tank" traffic of the old brick bridge near Bovington Camp to which reference was also made in the article. We now illustrate another type of arch bridge having virtual hinges at the springings which, with the assistance of the Ministry of Transport, has been erected to carry the Riverford road over the White Cart river at Glasgow. This bridge has to take exceptionally heavy loads, coming from one or other of the large engineering works established in the neighbourhood.

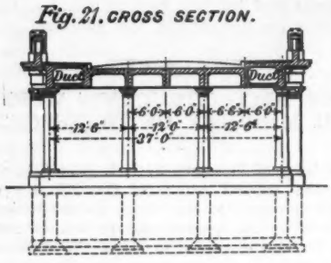
A general view of the structure is reproduced in Fig. 18, above, and the character of the construction and the type of abutment used is clearly indicated on the right of Fig. 19. The span is 80 ft. between springings, and the width between parapets is 60 ft. It is a skew bridge making an angle of 55½ deg. with the faces of the abutments.

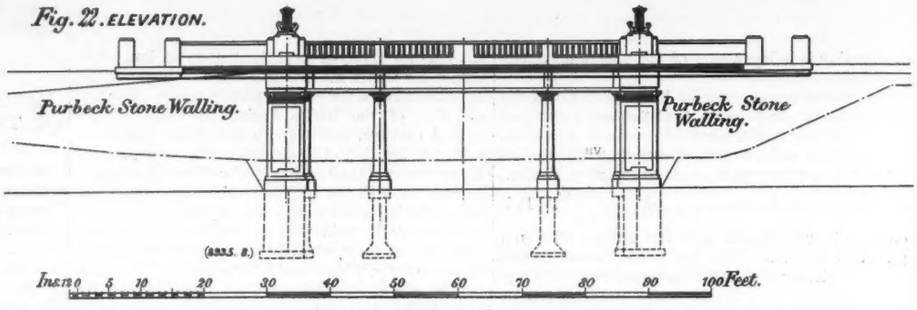
The arch is a continuous slab of reinforced concrete 9 in. thick. It is stiffened transversely by the ribs indicated to the right of Fig. 19, which assist in securing a fair distribution of concentrated loads. These ribs are 12 in. thick and project into the filling. The loading specified was a trailer having a total weight of 100 tons supported on four wheels with a 9 ft. gauge and wheel base. This trailer was assumed to be drawn by a number of heavy tractors, the weight of which had also to be considered in the design. The plans were prepared by Considére Constructions, Limited, of 72, Victoria-street, S.W.1, in co-operation with Mr. T. Nisbet, the late City Engineer, and his successor, Mr. T. Somers. The estimated cost was 18,100*l.*, of which one-quarter was provided by the Ministry of Transport.

It was, as already indicated, decided to construct the arch with virtual hinges at the abutments and it is the design of these hinges which perhaps

THE ST. STEPHENS BRIDGE, BOURNEMOUTH.

FIG. 20.



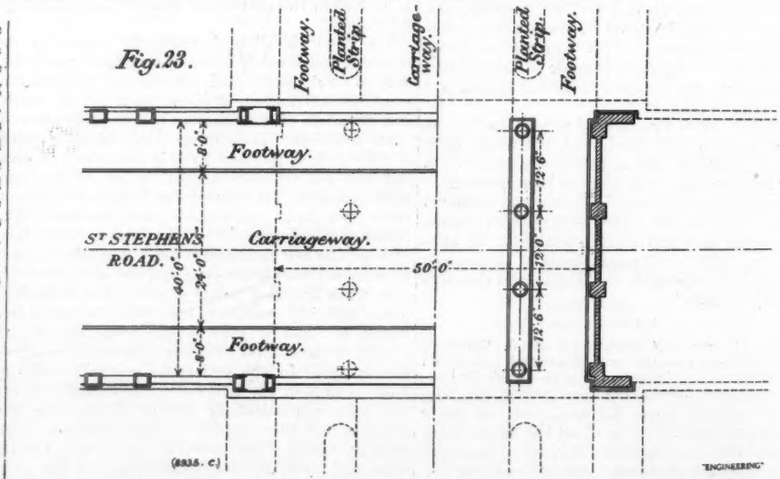


constitutes the most interesting feature of the bridge. The abutment beam, which takes the arch thrust, is constructed with a concave face, the radius of curvature being 2 ft. 6 in. The abutting extremity of the arch was given a convex surface, the radius of curvature being 1 ft. 6 in. This was formed *in situ* by means of a plaster mould secured to the abutment and removed after the concrete of the arch had been poured and hardened. Steel reinforcing bars pass from the arch through the line of contact into the abutment. These bars are arranged, not parallel to the line of the roadway, but make with it (in plan) an angle of 90 deg. This arrangement was adopted to provide against any tendency towards sliding which might be produced by the horizontal thrust of the arch acting on the skew line of the abutment.

Virtual hinges having been provided at the springings as thus described, it was necessary to make provision for free expansion of the spandril walls. These walls have, accordingly, been carefully separated from the wing wall and abutment structures by expansion joints provided directly above the springings. Movement in the neighbourhood of these expansion joints was observed during the construction and testing of the bridge, thus showing that the virtual hinges were functioning as they were intended to do.

The bridge abutments are of mass concrete, supported on reinforced concrete piles, some of which were driven on the batter. The maximum load at the level of the top of the piles is about 3 tons per square foot.

In testing the bridge the vehicles employed were 16 road rollers weighing 10 tons each, two steam tractors of 5 tons each, and four loaded trailers each of 9 tons gross. In a first test the whole of the above vehicles were crowded on to the bridge and kept stationary for three minutes. The total load



was 106 tons and the deflection at the centre of the span 0·018 in. In a second test three road rollers arranged abreast were run over the bridge from side to side. The maximum deflection was 0·003 in. After this six road rollers were run over the bridge, two abreast, the maximum deflection being 0·004 in. In a further test six road rollers were placed along one side of the carriageway and a train of 9 tractors and loaded trailers run over the bridge at full speed on the other side of the roadway. The deflection under this test was 0·008 in. A final test was made with two trains composed of a tractor and a loaded trailer, followed by three rollers, which were run at full speed in opposite directions across the bridge. The deflection was 0·003 in.

The contractors for the bridge were Messrs. Melville, Dundas and Whitson of Glasgow.

The bridge above described is intended to accommodate exceptionally heavy industrial traffic. As a contrast, it may be compared with the St. Stephen's Road bridge, erected at Bournemouth to carry St. Stephen's Road over a new by-pass road constructed by the corporation to relieve traffic congestion at the foot of Richmond Hill.

A general view of the structure is represented in Fig. 20, above, whilst an elevation, cross section and plan are reproduced in Figs. 21 to 23 which accompany it. As our engravings show, the bridge consists of reinforced concrete beams. Its overall length between abutments is 50 ft., but, as shown,

the beams are supported by columns along the line of the pathway kerbing of the under road, so that the main span is 26 ft. 6 in. The roadway is 24 ft. wide and on each side of this is a pathway 8 ft. wide. Ducts, measuring 4 ft. 9 in. by 2 ft. 3 in. in section, are provided for pipes or cables underneath these pathways, as indicated in Fig. 21. The eight columns which serve as intermediate piers are of reinforced concrete pre-cast. They are connected at the top by a heavy reinforced beam, with which they are monolithic, and this transverse beam is also monolithic with the main beams. The foundations for these columns and for the abutments were carried to a depth of 10 ft. below ground level, as indicated by the dotted lines in Figs. 22 and 23.

The decking is 8½ in. thick and is supported under the carriageway by five beams 23½ in. deep by 12 in. wide, and there is in addition at each outside edge of the pathways a beam 36 in. deep by 12 in. in section. The slabs supporting the pathway are 6 in. thick.

The superstructure was designed to carry a 25-ton vehicle with a maximum axle load of 15 tons, the axles being set at 10-ft. centres. The pathway was designed for a load of 1 cwt. per square foot. The test loads on completion consisted of two 13-ton road rollers, which crossed the bridge abreast, the maximum deflection being 0·018 ft. or 0·2 in. In a second test, an 8-ton roller was caused to follow the 13-ton roller, and the maximum deflection was 0·02 in. In a third test these rollers were sent across the bridge at their maximum speed of 5 miles an hour, and the deflection was then 0·03 in. At the completion of the tests no permanent set could be detected. The bridge was designed by Indented Bar and Concrete Engineering Company, Limited, acting in conjunction with Mr. F. P. Dolamore, F.S.I., the borough engineer. The contractors for the work were Messrs. Grounds and Newton, of Bournemouth. Financial assistance was given by the Ministry of Transport, to whom the plans were submitted for approval.

Both bridges have, it will be seen, a pleasing appearance, which has been attained without violation of the fundamental maxim applying to all bridge construction, viz., that the first object of a bridge is to accommodate traffic. Conscious striving after the beautiful as the leading motive in structural work is, in fact, apt to result in something akin to many undesirable products of the modern architect, whose dwelling houses, for example, seem not infrequently to have been designed with a view to providing a pretty photograph rather than in realisation of the fact that the main object of a house is to be dwelt in. In a circular just issued by the Ministry of Transport, stress is laid upon the importance of securing artistic effects. So long as this aim is controlled by the maxim that function must govern form, and not form function, there is everything to be said in favour of such a policy. The absurdities of "New Art" furniture, as developed by the so-called artistic designers of some 20 years ago, provide a striking illustration of the unfortunate consequences of ignoring this precept. Fortunately, the technical direction of the Ministry is in very able hands, so that we may feel insured against the perpetration of freak designs in the sacred name of art.

THE FORTHCOMING POLISH TRADE FAIR.—As a rule the attractions of the Continental trade fairs, held within the last year or two, have been somewhat lessened by the continuance of unstable currency conditions and lack of confidence in the permanency of the business connections which might be established through these events. This doubt applied to no traders more particularly than to those in Poland, yet strangely enough this is the only country in Europe repaying her debt to Britain. Poland possesses the advantage of a stable currency, which should prove of advantage in connection with the Trade Fair to be held at Posen from May 3 to 10 of this year. It is intended that on this occasion the Fair should be of an international character. The available space comprises an area of 350,000 square metres, that covered by concrete buildings, amounting to 40,000 square metres. Products of the engineering, metal, electro-technical, chemical, ceramic and other industries will be exhibited. Details regarding the Fair may be obtained from the British and Russian Transport Co., Limited, of 6, Lloyds Avenue, London, E.C. 3.

THE CHARACTERISTICS OF STEAM BOILERS.

R. H. PARSONS, M.I.Mech.E., M.E.I.C.

THE interest taken at the present time in the performances of steam boilers has resulted in the publication of innumerable figures from which a fair opinion may be formed about the results obtainable from any type of boiler plant—at any rate under test conditions. Almost every published boiler test has, however, been carried out with the object of showing the boiler or its equipment in the most favourable light and hence the plant has been tested at a steady load equal, as nearly as possible, to the rated full load output of the boiler. If one asks what the rated output of any boiler is, he is usually told the figure given in the maker's specification, but why the boiler should have that particular rating is a question not so easily answered. There was a time when a water-tube boiler was supposed to be steaming at full load when evaporating 3·45 lb. of water from and at 212 deg. F. per square foot of heating surface. This is the basis of the American system of rating so that when an American engineer states that his boilers are working at, say, 200 per cent. of their rating, all he means is that they are evaporating the equivalent of 6·9 lb. of water from and at 212 deg. F. per square foot. The American nomenclature in this respect is not worthy of imitation, and the custom in this country of calling the rating of a boiler the number of pounds of high pressure steam per hour which the makers guarantee it to produce, is not only much more logical but has a certain analogy in the way the word "rating" is used in connection with electrical machinery.

Competition between boiler makers has become so keen that there is a temptation to rate boilers at higher and higher evaporative capacities, so that the purchaser may be attracted by apparent cheapness. The average user, moreover, especially if he has really good feed water, is likely to prefer the boiler which will supply the required amount of steam with the smallest heating surface, because quite apart from the less cost of the boiler its smaller dimensions will effect a considerable saving in the cost of boiler house construction. Improvements in boiler design have also made higher evaporative capacities consistent with good efficiency, and if, as is usually the case, the manufacturer is willing to guarantee a satisfactory efficiency when the boiler is steaming at its rated capacity it might seem that the customer was not concerned with the basis upon which the boiler has been rated. If the boiler were always to be operated at its full load this view might be justified, but the ordinary power-station boiler has to work over a considerable range of load, and the modern tendency towards the use of a few very large boilers in place of a multitude of smaller ones greatly lowers the proportion of the time during which the rated load is being carried on any boiler. It becomes therefore of practical importance to know what sort of performance can be expected from a boiler when steaming at loads either less or greater than its nominal capacity. Very few data are available on this matter. It is commonly stated that there is very little difference between the efficiency of a boiler at full load and half load. If this is so, the full load rating must of necessity be somewhat vague, and the evaporative capacity might almost equally well be stated at some figure quite noticeably higher or lower than the one that has been selected. Hence the satisfaction which an engineer may derive from the belief that his boilers will be equally efficient over a large range of load must be tempered by the reflection that cheaper boilers with a lower nominal capacity might have given exactly the same results in practice.

The time has come when it would be reasonable to ask boiler makers to guarantee the performances of their plant at a number of different loads, exactly as the builders of the main generators always do as a matter of course with regard to their machines. In other words, the "characteristic" of any type of boiler plant should be stated to the purchaser, who would then be in a position both to select the type and size best suited to his conditions of load and to operate his boiler-house with regard to the maximum economy. It would furthermore protect those makers who adopt a conservative rating with a good overload capacity, and sustained efficiency, from the unfair competition of others who rate their boilers much nearer the limit of their efficient performance. It is also probable that the attention paid to the characteristics of a boiler might often prove fruitful in suggesting improvements in design, especially in regard to baffling arrangements, combustion chamber details and other factors which frequently exercise an unrecognised effect upon the overall performance.

Some interesting facts relating to the performance of a boiler over a large range of load are shown graphically in Fig. 1, on page 380. The data have been taken from Bulletin No. 214 of the American Bureau of Mines, and refer to a small boiler of the Babcock and Wilcox marine type having a heating surface of 2,500 sq. ft. and fitted with a four-pass arrangement of baffles parallel to the tubes. The working pressure was 200 lb. per square inch, and no superheater was fitted. In the diagram the relationship between the quantity of steam produced and the corresponding quantity of fuel burnt has been plotted for three series of tests. This method of plotting adopted has been chosen not merely because it shows in the simplest possible manner what the engineer is really concerned to know, but for the further reason that it enables the point of maximum efficiency to be directly determined, as will be seen later.

The uppermost curve, marked A, is a line formed by joining the points corresponding to six tests in which the rate of evaporation varied from 8,590 lb. to 22,028 lb. of water per hour. No attempt has been made to "smooth" the curve, for the smoothing of experimental data is a dangerous proceeding in the absence of any reliable theory as to the law of a curve. Hence, in drawing the line, one test has been neglected, as it appeared somewhat inconsistent with the others, but the point has been plotted near the upper end of the curve for reference. The tests which are represented by curve A were made when the boiler was fired by an underfeed stoker, having a grate area of 66·5 sq. ft. It will be noted that the line through the points has an upward curvature throughout its length, showing that the coal consumption is tending to increase at a progressively faster rate. This does not mean that the efficiency is falling the whole way along the line, for the efficiency does not begin to fall until the increase in fuel consumption is at a faster rate than the increase in the quantity of water evaporated. Hence, if a tangent to the curve is drawn through the point of origin, the point at which this tangent touches the curve will be the point of maximum efficiency. Beyond this point every increase in the rate of evaporation is accompanied by a progressively greater increase in the rate of fuel consumption.

The tangent to curve A, which passes through the origin, is shown dotted in Fig. 1. It touches the curve at a point corresponding to a fuel consumption of about 1,180 lb. per hour and an evaporation of 10,940 lb. per hour. On either side of this point the fuel consumption per pound of water evaporated will be greater, showing that the point of maximum efficiency has been found. From the dimensions of the boiler and grate which have already been given it will be seen that maximum efficiency occurs when coal is being burnt at the rate of about 17·9 lb. per square foot of grate area, and when water is being evaporated at the rate of 4·86 lb. per square foot of heating surface. These are interesting figures, but of much more interest is the question why the efficiency falls off at this point. Before the point is reached it steadily increases, the reason being that the constant and irreducible losses, such as radiation, &c., become of proportionally less and less importance as the output of the boiler is increased. The same conditions, of course, hold after the point, but clearly something else is occurring which neutralises and then overcomes the gain from the cause mentioned, so that the net result is a loss of efficiency. There are two possibilities. It may be that the combustion of coal is less perfect as the rate of burning is increased, so that the losses in the flue gases or in the ashes become greater, or, on the other hand, it may be that the boiler surface is incapable

of absorbing the same percentage of the available heat when more coal is burnt. In other words, the question is whether it is the fault of the furnace, or of the boiler, or both, that the efficiency falls off after the evaporation has reached the value of 4·86 lb. per square foot of heating surface.

Valuable light is thrown upon this question by the curve B in Fig. 1. This curve is formed by connecting the plotted results of five further tests upon the same boiler, these tests having been carried out with oil fuel and the conditions being exactly the same as when coal was used, except, of course, that oil burners were fitted instead of the mechanical stoker. It will be noted that the whole of the five tests lie on what is practically a perfectly straight line passing through the origin. The direction of the line and the absence of any curvature indicate that throughout the whole range of the tests in which the evaporation varied from 6,251 lb. of water per hour to 17,007 lb. per hour, the efficiency was perfectly constant, the rate of evaporation being practically equal to 11·9 lb. of water per pound of oil whatever the rate of firing. At the greatest load at which the boiler was tested with oil fuel, the evaporation was at the rate of 6·80 lb. of water per square foot of heating surface. There is apparently no sign of any falling off of efficiency when the boiler is steaming at this rate, although, as we have seen, the same boiler began to lose efficiency when evaporating only 4·86 lb. of water per square foot when fired with coal. It seems fairly evident, therefore, that the boiler, as such, had by no means reached its limitations at the point of maximum efficiency in the first series of tests, but that the falling off was in some way due to the less efficient combustion of the fuel at higher rates of firing. This is an important conclusion, and the effect of the tests is to show that it is impossible to state the most efficient rating of any boiler without reference to the furnace conditions under which it will work.

Curve C in Fig. 1 shows a series of tests made upon the same boiler, but with different oil burners, and conveys substantially the same lesson as curve B, although the test results are not so consistent as in the latter curve.

A set of tests made upon another oil-fired boiler is shown graphically in Fig. 2. The boiler in this case was of the Foster type, which is generally similar to the Babcock and Wilcox marine type. It was rather larger than the boiler previously considered, having a heating surface of 3,050 sq. ft. and, furthermore, being fitted with a superheater of 528 sq. ft. arranged between the passes. The working pressure was 200 lb. per square inch, and the temperature of the steam 440 deg. F. Nine tests are recorded in Fig. 2, the quantity of water evaporated per hour ranging from 9,253 lb. to 16,683 lb. A straight dotted line has been drawn on the chart, passing through the origin. This, as will be seen, conforms remarkably well with the positions of nearly all the plotted points, showing that the efficiency of the boiler was substantially constant over the greater part of the tested range. The points do not appear to curve upwards until after an evaporation of 16,000 lb. per hour, or 5·24 lb. per square foot of heating surface has been reached. If the last two plotted tests are accurate, and there is no more reason to doubt them than any of the others, it would appear that the evaporative efficiency on these tests had commenced to fall off, although the rate of evaporation per square foot was still far less than the boiler previously discussed had attained without any loss of efficiency. On the other hand, it will be noted that throughout its efficient range the Foster boiler evaporated about 12·9 lb. of water per pound of oil, whereas the Babcock and Wilcox boiler evaporated almost exactly 12 lb. at all loads. These figures, however, do not take into account any differences in the quality of the fuel or of the steam in the two cases, and will not be further considered as the present object is not to make any comparison of absolute efficiencies, but rather to draw attention to the characteristic performances of given boilers at different loads.

The performances of a Scotch marine boiler, with different methods of firing, are shown in Fig. 3. The boiler was of the single-ended type, 15·25 ft. diameter by 11·42 ft. long, and with a working pressure of 190 lb. It had three furnaces, each 45 in. diameter by 8·27 ft. long, and when fired with coal in the usual way the heating surface was 2,777 sq. ft., and the grate area 61·8 sq. ft. When arranged for oil firing the grates were removed, and the consequent addition of the lower half of the furnaces to the heating surface raised the area of the latter to 3,022 sq. ft. Curves A and B in Fig. 3 show the results of two series of tests with the boiler fired by hand. In each series a different type of air heater was fitted, but otherwise the conditions were the same, retarders being used in the tubes in both cases. The dotted line drawn through the lowest point of curve B might perhaps be taken to show that the efficiency started to fall off at an evaporation of 12,400 lb. per hour, or 4·46 lb. per square foot of heating surface with a coal consumption of 19·4 lb. of coal per square foot of grate area. The point, however, is very indefinite, and the shape of the curves, with their apparent tendency to droop downwards at the highest load, rather than turn more and more upwards as might be expected may be due rather to the inevitable irregularity of hand firing than to any inherent characteristic of the boiler.

Curve C in Fig. 3 refers to tests of the same boiler when fired with oil. The dotted line drawn through the lowest point seems to indicate a continuous slight decrease in efficiency throughout the whole range covered by the tests. If, however,

Fig. 1. 4 PASS B & W MARINE BOILER. COAL & OIL FIRED. HEATING SURFACE 2500 SQ. FT.

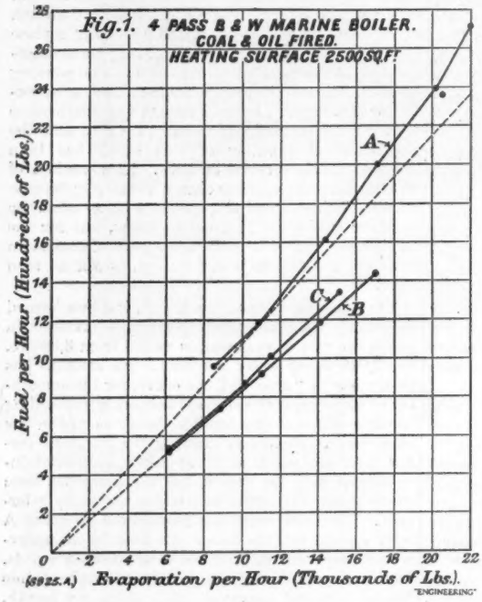


Fig. 2. FOSTER BOILER. OIL FIRED. HEATING SURFACE 3050 SQ. FT. SUPERHEATER . 528 "

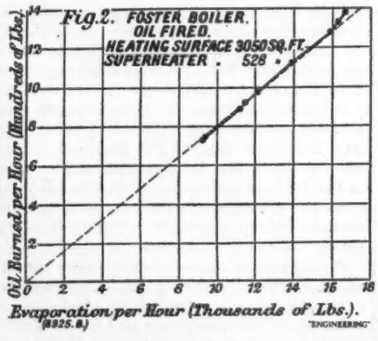


Fig. 3. SCOTCH MARINE BOILER. 15·25 FT. DIA. X 11·42 FT. LONG. WITH DIFFERENT METHODS OF FIRING.

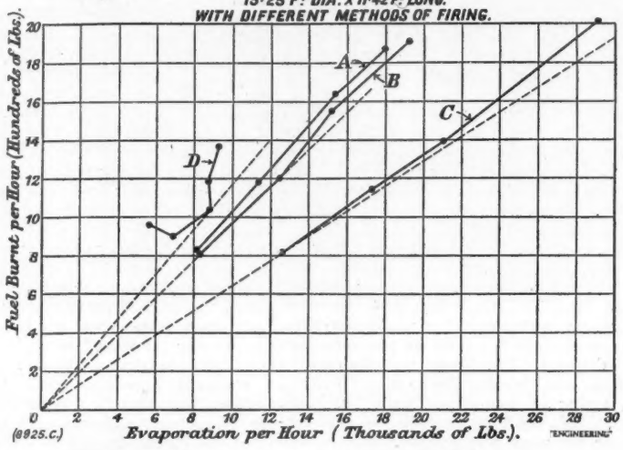


Fig. 4. STIRLING BOILER. HEATING SURFACE 10,134 SQ. FEET EQUIPPED WITH UNDERFEED STOKER.

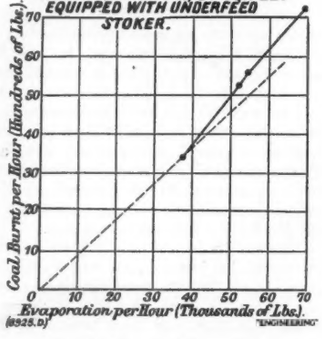
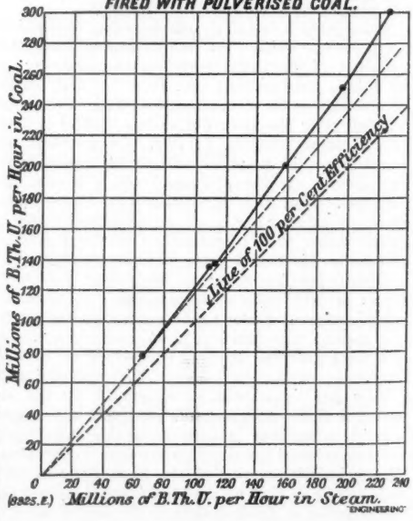


Fig. 5. BABCOCK & WILCOX CROSS DRUM BOILER. HEATING SURFACE 15,326 SQ. FT. FIRED WITH PULVERISED COAL.



the lowest point is regarded as slightly doubtful, and just a little lower than it should be, then it would appear that there was no sensible falling off in efficiency until the evaporation reached about 21,000 lb. per hour, or 6·95 lb. per square foot of heating surface. Even then the rate of falling off is very slow, as shown by the flatness of the curve. The fuel oil used in this series of tests was exactly the same as that with which the tests shown in curve B in Fig. 1 were carried out. The steeper slope of the line in the latter case indicates that the Scotch boiler was capable of evaporating a given quantity of water with less oil than the other type, and indeed it is evident from other figures with which we are not now concerned, that the Scotch boiler surpassed both the B. and W. and the Foster water-tube types in efficiency, both when burning coal and oil. It is stated by the authors of the tests that in the case of hand firing the flue gas losses due to high temperature and the presence of carbon monoxide reduced the efficiency of the water-tube boilers, while when oil firing was used the greater radiation loss of the water-tube boilers was the cause of their lower efficiency.

The set of points marked D on Fig. 3, which resemble somewhat the configuration of the "Great Bear" constellation, indicate the results of a series of tests made on the Scotch boiler with pulverised coal as fuel. The furnaces were lined with firebricks 1 in. thick, and the powdered coal was fed axially along the centre of each furnace. The tests lasted from six to eight hours each, which should be long enough to get reliable results with such a fuel as powdered coal, but the figures which were obtained were both bad and erratic. The overall thermal efficiency with powdered coal firing varied from 49 to 68 per cent. over a small and easy range of steaming. The efficiency was considerably worse than with hand firing because a large quantity of unburnt fuel escaped up the stack, the loss due to incomplete combustion being estimated as at least 20 per cent. of the fuel. The combustion space was 539 cub. ft. on the pulverised coal tests, as compared with 467 cub. ft. for hand firing, and the rate of burning the pulverised coal varied from 1·5 lb. to 2·3 lb. per cubic foot of combustion space in the five tests recorded. At the most efficient, or rather the least inefficient, of the tests, through which the dotted line has been drawn, coal was fed into the combustion space at the rate of 1·8 lb. per cubic foot per hour. No conclusion ought to be drawn from the curve D other than that a Scotch marine boiler is not well adaptable for powdered coal firing.

The curve shown in Fig. 4 represents a series of published tests of a Stirling boiler working with an underfeed stoker. The boiler is of considerable size, the heating surface being 10,134 sq. ft., so that it represents modern practice in an average size station. In this case the figures of evaporation are "from and at 212 deg. F.," so that differences due to varying steam pressure and temperature are eliminated. It will be noted that the four test results, ranging from an evaporation of 3·68 lb. to 6·83 lb. per square foot of heating surface, fall almost exactly on a straight line, no upward curvature being apparent. The efficiency, however, is falling off over the whole range at a practically steady and fairly rapid rate. It seems likely that the most efficient rate of evaporation would be well below the 3·68 lb. rate, but in the absence of any data below this point, the matter must be left to conjecture. It is certain that a continuation of the curve to the left would cut the vertical ordinate at some point above zero, the intercept representing the coal required for banking the boiler for an hour, but this is all that can be said. At what output a boiler with the characteristic shown should be commercially rated, or at what output it should be worked, taking capital cost as well as fuel consumption into account, are problems of a kind which deserve the attention of engineers.

In all the tests so far considered, the fuel consumed per hour has been plotted against the quantity of water evaporated, the assumption being tacitly made that both the heating value of the fuel and the quality of the steam were substantially constant for each series of tests. For practical purposes this assumption is justified, for not only is it, of course, the endeavour of those in charge of a test to maintain these conditions unchanged, but any effort to be more scientific brings in questions of the correctness of calorimeter figures, pressure gauges and thermometers and other matters and may easily produce a false feeling of accuracy. The elimination of apparent variations of efficiency due to varying quality of fuel or steam may be made by plotting the total heat units fed into the furnace per hour against the total heat units in the steam produced. This has been done in the case of a large Babcock and Wilcox boiler fired with pulverised coal, the graph being shown on Fig. 5. The tests, which were made for commercial reasons, are believed to be of great accuracy, and as they varied in length from 22 to 45 hours each, the influence of starting and stopping conditions should be negligible. The boiler in question had a heating surface of 15,326 sq. ft., with a water screen having an additional 480 sq. ft. of surface at the bottom of the combustion chamber, and a superheater surface of 3,860 sq. ft. No economiser was fitted.

It will be seen from Fig. 5 that the test results lie on a very flat curve sloping upwards, the curvature being so slight that it is almost negligible over any short portion of the range. The lowest and highest points of the curve correspond respectively to evaporation rates of 3·38 lb. and 11·22 lb. of water per square foot of heating surface, including the water screen. The dotted line through the lowest point of the curve shows that the smallest load was the most efficient of the loads at which the boiler was tested, and indicates by its distance from the curve at any other point, to what extent the efficiency has fallen away at that particular load. As in the case of the Stirling boiler, Fig. 4, it would seem that the most efficient load is lower than the lowest at which the boiler was tested, and consequently far below the normal working load. The efficiency, moreover, falls off at a slowly increasing rate as the load is increased. With the system of plotting adopted in Fig. 5, the ratio of the horizontal to the vertical ordinate at any point of the curve gives the actual efficiency figure at that particular load, which is a great convenience of the system. It follows, therefore, that a line drawn at 45 deg. through the origin corresponds to an efficiency of 100 per cent., so that the vertical distance between the plotted curve of test results and this line is an exact measure of the heat losses per hour at any load. The line has been drawn on Fig. 5, and its increasing divergence from the test results shows how the heat losses increase as the load goes up. When an efficiency curve is drawn in the usual way it conceals the fact that a loss of, say, 20 per cent. is twice as serious at full load as at half load in actual quantity of coal wasted, whereas by setting out test figures in the manner shown, the amount of coal or of heat lost by inefficiency at any load is quite clearly brought out. It is evident, for example, from Fig. 5 that when the boiler in question is steaming at such a rate that 220 million B.Th.U. are being delivered per hour in the form of steam, about 290 million B.Th.U. have to be expended per hour in the form of coal. The difference between these figures represents the waste of some two or three tons of coal per hour by various kinds of loss at this particular load. Supposing that the efficiency could have been maintained at the figure obtained when the evaporation was only 65 million B.Th.U. per hour, the losses at the higher load would have been reduced from 70 to 40 million B.Th.U. per hour, so that 30 million B.Th.U. per hour in the form of coal are being expended merely for the sake of getting the larger quantity of steam out of a simple boiler. It may well be, of course, that there is true economy in doing this, on account of the large capital expenditure which would be entailed in providing sufficient boilers, or heating surface, to generate the same quantity of steam at the lower rate of evaporation, but it is well that the cost in fuel should be realised.

Enough examples have been given to indicate the general nature of the performance to be expected from various types of boilers operated at different loads. With every type it would appear that the maximum efficiency occurs at a very low rate of evaporation. This efficiency is maintained over a long range with oil firing, but a much more decided falling off is found with stoker firing. With pulverised coal firing the efficiency is also fairly well maintained, but comparative results with a good modern stoker plant are needed to give definite information about the variation of efficiency with load in the respective cases. It seems clear, nevertheless, that however the coal is fired, high rates of evaporation are not consistent with the maximum efficiency. This is not to say that one type of boiler steaming at a high rate per square foot may not be more efficient than another type working at a lower rate. Such may well be the case, but it in no way alters the inference from the curves that, in any particular boiler a low rate of steaming is more efficient than a high one, the words "low" and "high" relating to rates within the range of current practice. In some of the curves given the point of maximum efficiency would appear to be so low that the question inevitably arises whether it would not be more economical in a power station to keep all boilers on the line as long as possible, reducing their output equally when the load is light, in preference to banking some and running the others at full load. The consensus of opinion among power station engineers is certainly that the latter is the most economical practice, but this and other points could be determined with certainty if the characteristics of the boilers were experimentally determined over their whole range.

HIGH-PRESSURE COMPOUND 2-8-0 TYPE LOCOMOTIVE.

LAST year we mentioned in ENGINEERING (vol. cxvi, p. 630) that the Delaware and Hudson Company had celebrated its centenary. This company was first interested in mining, and then was concerned with the question of getting its products to the markets and ports. It was not until 1829 that the company possessed a steam locomotive, the first orders for such machines being completed by English firms. These orders were placed as a result of a visit to this country by Mr. Horatio Allen, the company's chief engineer, one engine being ordered from Messrs. Robert Stephenson and Co., of Newcastle, and three from the firm of Foster, Rastrick and Co., of Stourbridge. Actually Messrs. Stephenson can claim the credit of first delivering an engine on American soil. This engine, landed at the close of 1828, was held up in New York, and it was one of the Stourbridge locomotives which was the first to run on the American continent. This machine was known as the "Stourbridge Lion," and on the first occasion was driven by Mr. Allen himself, this event taking place in 1829.

At the beginning of December last the officials of the Delaware and Hudson Company indulged in another little celebration. The occasion was the "christening" of a new locomotive which was named after the company's pioneer engineer, "Horatio Allen." The locomotive in question is a machine of quite unusual character. It is an evolution of design for which Mr. J. E. Muhlfield is responsible. Mr. Muhlfield has left many marks on American locomotive design. He was for long keenly interested in the two-cylinder or cross compound. He was later responsible for the first large Mallet in the country, this being introduced on the Baltimore and Ohio R.R., the design and size of the machine altogether outclassing anything previously attempted in engines of the type. The rapid adoption of the Walschaert valve gear in America was also largely due to Mr. Muhlfield's advocacy, and now, as consulting engineer to the Delaware and Hudson Company, he has produced a design which is in many respects absolutely radical in its departures from accepted practice. The "Horatio Allen," No. 1400, of the Delaware and Hudson Company, is illustrated in Figs. 1 to 8, Plates XXVI and XXVII, accompanying this week's issue of ENGINEERING. The engine was built by the American Locomotive Company at its Schenectady works, and it is through the courtesy of the American Locomotive Sales Corporation, of 26, Victoria-street, S.W.1, that we are able to give particulars of this interesting machine. From our illustrations it will be seen what unusual features the engine possesses, though many are not, of course, so readily apparent.

In the first place, the engine uses an exceptionally high boiler pressure, viz., 350 lb. per square inch, together with a water-tube fire-box, superheating, and compound cylinders. The engine is of the consolidation class, with a short wheelbase and a

two-wheeled truck, and has been designed for a maximum tractive effort with a machine easy on the track.

The boiler is the most noticeable novelty. Of this, three views are given in Figs. 2, 3, and 4. The main parts of the firebox consist of two upper horizontal drums, 32 7/16 in. in diameter, and two bottom drums, 21⅝ in. in diameter, joining two vertical water legs or headers made of flat plates and stayed. These take the usual place of the throat sheet and back head, and in outline are approximately of the usual fire-box shape. The pairs of water and steam drums are connected by vertical rows of 2-in. tubes. Of these there are 51 in each row fore and aft, and 6 in each row across the drums, making a total of 306 tubes on each side of the box. The box is connected at the front end to a short length of barrel of two courses of 1 1/16-in. plate, 64 in. in diameter. The length between tube sheets is 15 ft., a great contrast to the usual modern high-powered American locomotives. The barrel accommodates 145 2-in. tubes and 42 5-in. superheater flues. In addition, between the two upper drums in the roof of the fire-box, are eight 3-in. tubes. Over the barrel are two horizontal drums, which constitute extensions of the upper fire-box drums continued beyond the front fire-box water leg. The front ends of these extension drums are connected to the barrel by headers of flanged plate, stayed where flat. The width of the water space in these and the main firebox headers is 9 in. In all cases the headers are made of two flat plates flanged towards each other round the edge so as to make single riveted lap joints.

The drums pass, in all cases, right through the headers. The openings in the latter plates are flanged outwards and single riveted to the drums which are liberally perforated over the 9-in. length running between the header plates. The ends of the drums are made of dished plates with flanged central openings closed by manhole cover and cross bar. Each extension drum is connected with the upper part of the barrel by means of two elbows of 6½ in. internal diameter. Water is kept up to a level of about 3 in. below the axes of the top drums. Steam is drawn from the top drums through an opening in each of the extension lengths communicating with a single Y-shaped casting placed in the space between the two drums. Strainer pipes are fitted inside the drums while a centrifugal separator is further arranged in the Y casting. The latter also has connections leading to the injectors and steam turret in the cab. The steam for the auxiliaries is separately superheated in elements arranged on the roof of the firebox above the eight 3-in. tubes previously referred to as placed between the two upper firebox drums. From the Y-shaped collector casting, the main steam pipe runs forward to a duplex throttle, situated on the top of the barrel about where the drums end. This fitting is shown in Fig. 7, Plate XXVII. It consists of two valves operated by one gear by a lever in the cab. One valve, the first to come into operation on a movement of the throttle lever, admits steam at 300 lb. pressure to the cylinder; further movement operates the second valve which allows of full pressure being brought into use. From the duplex throttle, steam passes into the superheater header. This is a single casting, illustrated in Fig. 8, Plate XXVII. This casting is placed horizontally covering an opening 55 in. by 25½ in. in the top of the smoke box. The upper side of the casting is shown in Fig. 8, the flanged aperture shown at the top being that connected with the throttle casting while the collector is shown below gradually swelling up to a 7½ in. flanged connection leading to the h.p. cylinder. The steam pipe to the h.p. cylinders is well seen in Fig. 5, Plate XXVII.

Before proceeding further we may consider the superheater. In an article in ENGINEERING in 1914 (Vol. xcviii, page 18), we discussed the effectiveness of the common form of return-bend type of superheater element and pointed out that, so far as effective heat transmission was concerned, a large portion of the length of these elements was valueless and might safely be cut out. It was suggested that the return bend could be shortened without any serious loss. It is interesting to note that in the large 4-6-2 type engines of Mr. Gresley on the L.N.E.R., the return loop has been shortened, and, we gather, with results similar to those we anticipated. Proceeding to discuss further developments with a view to greater effectiveness of superheater surface, that article of nearly eleven years ago said: "it is impossible in the present smoke-tube system to get rid of the last limb leading the steam back to the smoke box, but the present useful, or additional, heating surface might be concentrated in the hot zone in the form of an open corkscrew spiral at the firebox end of the first limb, the single return member running back from the end nearest the firebox through its centre." In the engine now under discussion this very principle has been adopted. Each element consists of a single tube, which, on entering its smoke tube in the boiler, is bent into a helix or corkscrew. This is continued to within 12 in. of the firebox tube plate where it bends back and is carried to the smoke-box again through the centre of the helical length. This increases the heating surface per element and reduces expansion stresses as well as having other advantages. In this particular case, there are 42 elements, but a very high degree of superheat is not aimed at, a total temperature of not more than 600 deg. F. being considered to be as high as desirable until more is known of the effect of working with such a high pressure as 350 lb.

An interior view of the firebox is shown in Fig. 4, Plate XXVI. Extending from the front water leg to the back header, as will be seen, are six arch tubes. The brick arch supported on these tubes extends right to the back of the box with the object of making the flames pass among the side water tubes in order to get to the upper side of the arch, and so to the flues in the barrel. A long path for the gases is thus secured, ensuring good combustion before they enter the barrel tubes. The boiler is fired with a mixture of bituminous coal and anthracite. We understand that the novelty of the design of the boiler was such that the builders consulted with Messrs. Yarrow and Co., Limited, before embarking upon construction. On this firm's report being favourable, the boiler was built, and has, we gather, fulfilled all expectations in service since the engine has been at work.

From the high-pressure cylinder the steam is passed to the low-pressure (left-hand) side of the engine, by a large pipe running over the smoke-box front, as will be seen in Fig. 5, Plate XXVII. The pipe acts as the receiver. The h.p. side is fitted with an intercepting and starting valve. This is a slightly modified form of the Mellin type used on the so-called "Richmond" compounds, 20 to 30 years ago, built by the then Richmond Locomotive Works, since absorbed in the American Locomotive Company. It is not necessary to explain the working of this device. It will suffice to state that in the ordinary way it functions so as to allow live steam at reduced pressure to pass to the low-pressure cylinder at starting, but as soon as the receiver pressure builds up, this supply of live steam is automatically cut off and the engine starts operating compound. On the other hand, if the driver desires, the engine can be worked as a simple machine at any time.

A good view of the cylinders is given in Fig. 6, Plate XXVII. These also present many unusual features of design for American practice. The cylinders are not cast with the usual half-saddle, but each, with its steam chest embodied in the casting, is fastened to the outside of a front-frame casting. This front section of the frame is peculiar. The main frames to the rear of the cylinders are of the usual American bar type, but the front portion to which they are fixed consists of a rather complicated casting formed mainly of a large box-shaped portion on each side of which the cylinders are fixed. Vertical extensions run back from the side of this box-shaped part to provide connection for the bar frames. Again, forward from this box or saddle, the casting is continued out to the bumper or buffer beam in front, very strongly ribbed, and providing an effective housing for the pivot casting of the leading two-wheeled truck. Properly speaking, the box-shaped part of the front frame is not the saddle in this case. A light saddle casting is interposed between the frame casting and the smoke-box. The exhaust from the l.p. cylinder is carried through the frame casting to the blast pipe in the smoke-box by an outside elbow.

The locomotive weighs 155·4 tons of which 133·3 tons are on the drivers. The tender in working order weighs 88·3 tons. It is fitted with two four-wheeled trucks, of which the trailing one carries a booster engine, the four wheels being coupled. Tests have shown the engine to develop, at 4 m.p.h. in simple gear, a draw-bar pull of 95,000 lb. In compound gear at 5 m.p.h., the pull is 75,000 lb.; at 8 m.p.h., 67,000 lb., and at 10 m.p.h., 65,000 lb. At starting and with the booster working with 150 lb. steam-pressure, the draw-bar pull developed is 105,000 lb.

The following table gives the chief particulars of this interesting machine:—

Locomotive:—	
Diam., H.P. cylinder	23½ in.
,, L.P. ,, ...	41 in.
Stroke	30 in.
Wheels driving diam.	57 in.
Boiler barrel diam.	61⅞ in.
,, length between tube plates ...	15 ft.
Barrel tubes, 2 in. diam., number ...	145
,, ,, 5⅜ in. diam. ,, ...	42
Firebox length	11 ft. 5 in.
,, width	6 ft. 3 in.
,, Diam. of lower drums ...	21⅝ in.
,, ,, upper drums ...	32 7/16 in.
,, ,, tubes	2 in. and 2¼ in.
,, ,, arch tubes	3½ in.
Heating surface barrel tubes	1,132 sq. ft.
,, ,, 5⅜ in. flues	281 sq. ft.
,, ,, firebox	1,124 sq. ft.
,, ,, arch tubes	63 sq. ft.
Locomotive—(continued):—	
Heating surface total	3,200 sq. ft.
Superheater number of elements ...	42
,, heating surface	579 sq. ft.
Grate area	71·4 sq. ft.
Ratio Firebox H.S. / Total evaporative H.S. ...	57 per cent.
Working pressure	350 lb./sq. in.
Wheelbase driving	18 ft.
,, engine	29 ft.
Weight on leading truck	22·1 tons
,, drivers	133·3 tons
,, engine total	155·4 tons
Tender:—	
Coal capacity	15½ tons.
Water ,, ...	9,000 gallons
Weight ,, ...	88·3 tons
Locomotive and Tender:—	
Total wheelbase	65 ft. 7½ in.
,, weight	243·7 tons

THE HARDENING OF CARBON TOOL STEEL.*

By S. N. BRAYSHAW.

IN contrast to the well-established heat-treatment operations of alloy steels, there is, in the hardening of carbon tool steel, a marked degree of uncertainty, and the surprising fact stands out that this state of things is generally accepted as inevitable and beyond remedy. In order to find a treatment by which a steel giving the following analysis, C., 1·13 per cent., Mn., 0·34 per cent., Si., 0·14 per cent., Cr., 0·18 per cent., W., 0·8 per cent., Ni., nil, V., trace, and S and P low, could be hardened with reasonable certainty of producing a thoroughly good cutting edge without risk of cracking or warping, a large number of small test cutters were made. They were machined alike within fine limits so that their response to various heat treatment processes might be affected as little as possible by chance conditions. After hardening they were dried, soaked in oil and sand-blasted; hardening cracks could then be detected by the appearance of the oil on the sand-blasted surface.

After some years of experiment, the remarkably good results obtained from cutters made from a chance bar urged the author to pursue the investigation further. Being convinced that the best results obtainable from carbon tool steel depended not so much upon the final quenching as upon the previous heat-treatment, a series of 102 blanks was made from 2½ in. round bars specially produced from the same ingot. Accurate control of temperature being of paramount importance, all heating operations were conducted in salt-bath furnaces, two of which were used. The regulation of the temperature in the first furnace was the less important and, for this reason, an iron-constantan thermo-couple was used as a pyrometer. In conjunction with the second furnace a platinum-resistance thermometer and Callendar recorder giving great accuracy were utilised. A hardening treatment uniform for all the test cutters was adopted by which each piece was heated direct from the cold to 760 deg. C., and kept there for 15 minutes; it was then plunged into water at a temperature of 10 deg. to 13 deg. C., for about half a minute.

Of the 102 test blanks above referred to, two were machined in the ordinary condition as received and then hardened; as expected, they both broke badly. The remaining 100 blanks, after normalising at 825 deg. C. for one hour, were allowed to cool out in air. Two of these were machined and, as before, they broke badly upon hardening. Every one of the remaining blanks received a different heat treatment. Most of them were first heated for an hour in the first furnace to a temperature of 750, 800, 850 or 900 deg. C., and were then transferred as quickly as possible to the second furnace, which was already settled at a temperature below the hardening point, and the soaking continued for times varying from one-quarter of an hour to 16 hours. They were then cooled slowly in sand. The subsequent hardening was carried out as indicated above.

From a general inspection of all the results obtained from these cutters, it was evident that there was a range of temperature, lying somewhere between 715 and 728 deg. C., within which, with prolonged soaking, the steel under consideration reached a condition in which the liability to hardening cracks was reduced to a minimum. Other classes of tool steel will, in the author's opinion, respond in similar fashion and the annealing treatment necessary before hardening might be determined in analogous fashion. This treatment would practically eliminate the risk of distortion or breakage and the hardener would have no need, as is now the case, to modify the hardening treatment for

* Paper read before the Institution of Production Engineers, London, on March 20, 1925. Abridged.

THE SUREAL SELF-ACTING DAVIT.

Fig. 1.

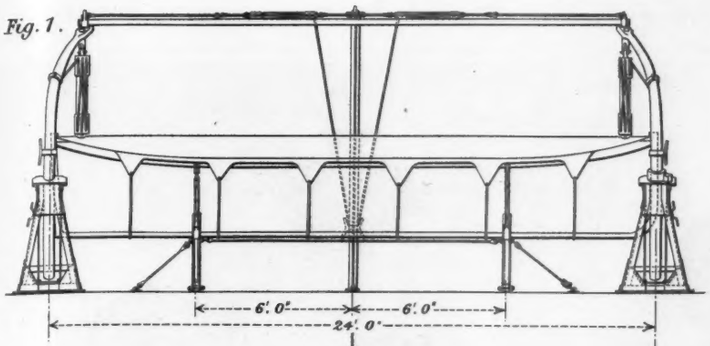


Fig. 2.

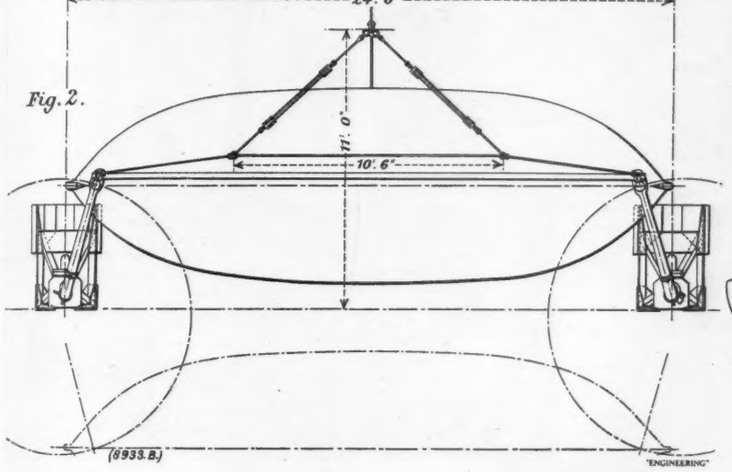


Fig. 3.

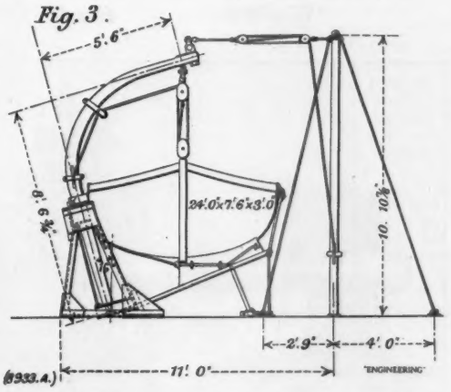
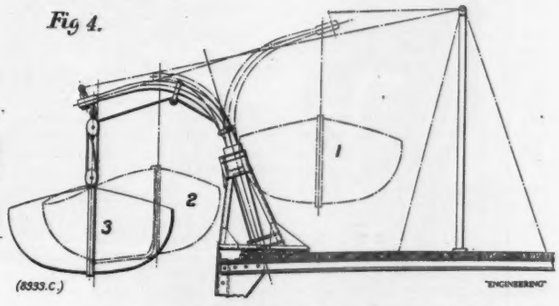


Fig 4.



fear of warping or cracking. He would have confidence in heating and quenching his work regardless of any consideration other than the production of the best possible cutting edge or wearing surface.

THE SUREAL SELF-ACTING DAVIT.

A LARGE number of patent davits have been introduced with the object of overcoming the difficulties associated with the lowering of boats in unfavourable circumstances, as, for example, when the ship takes a heavy list, and more than one of these embody the principle of utilising the weight of the boat itself to perform the launching operation. Amongst those of the latter type is the "Sureal" davit, introduced by Messrs. James Pollock, Sons and Co., Limited, 3, Lloyd's-avenue, E.C. 4, which we illustrate above and on page 388. This davit is noticeable for an entire absence of complicated mechanism. The latter feature is a most desirable one, as the circumstances under which the boats may require to be cleared in an emergency render certain operations essential.

As will be seen from the illustrations, the davit arms are housed in pedestals built up of plates and angles, and the axis is given an inclination of 16 deg. from the vertical in an outboard direction. The heads of the two arms are connected by a tie rod, and the axes of the bolts which form the bearings for the tie rod are parallel to the axes of the davits. The distance between the tie-rod centres is less than that between the pedestal centres, and the davit arms therefore incline towards each other, whether in the inboard or outboard position. An overhead tackle is run from each of the davit arms to an upright stanchion, fixed to the deck between the davits or to a deck-house, this arrangement resulting in a clear deck space.

In use, on the collapse of the boat chocks, the inclination of the axis of the davit results in a state of unstable equilibrium, but movement is prevented by the tension in the davit tackles. When the latter are slacked off, the davit arms, which are prevented from swinging forward by a stop on the forward housing, first of all swing aft, on account of the weight of the boat, until the fore end of the boat is able to swing outward. The boat is then in the position shown in Fig. 6, on page 388. After this position is reached, the weight of the boat again effects the outboard movement, causing the boat, as the tackle is further paid out, to swing forward until the after end comes clear, when this also swings outboard and the boat comes to rest in the position shown in Fig. 7. Lowering is then performed by slacking out the boat falls in the usual way. When the boat is exceptionally heavy, a brake may be fitted to the davit to facilitate control when putting out. The inclination of 16 deg. given to the davits is sufficient to ensure that the boat will swing out by its own weight against any list that is likely to be met with in actual service. Fig. 5 shows the boat housed on the chocks, and Figs. 1 to 4 show the mechanism in detail. The path of the davit heads is indicated by the dot-and-dash lines in Fig. 2, and the three positions of the boat in end elevation are shown in Fig. 4.

Amongst other advantages of this mechanism, it may be mentioned that the swinging out of the boat lowers its position approximately to the level of the deck without it being necessary to slack out the boat falls. The boat can be checked in position 2 (Fig. 4), if required, thus facilitating manning before it is completely swung out. The point round which the davit turns is situated well outboard, so that the latter have a greater spread in that direction than inboard, resulting in the boat swinging well clear of the ship's side. Owing to the low position of the points of suspension, damage to the boat through striking the ship's side when swinging, due to the roll of the ship, is unlikely. The davits can normally be handled by one man, and even under the most severe conditions two men can do all that is required. The distance between the davits is such that the boat can be effectively handled even when the ship is down by the head or stern.

WIRELESS IN SCHOOLS.—An exhibition of wireless apparatus made by scholars and of wireless sets used in schools for the reception of the educational lectures broadcast by the British Broadcasting Company, was held at the Beaufoy Technical Institute of the London County Council, Prince's-road, S.E.11, from the 14th to the 18th instant. The exhibition was organised by the Schools' Radio Society, which was formed a year or so ago for the purpose of fostering the use of wireless for educational purposes, not only by broadcast lectures, but also as a form of manual training and an interesting and instructive application of physical laws. About 40 schools and other institutions displayed examples of the work of their scholars, mostly in the form of crystal or valve receiving sets, and one or two manufacturing concerns exhibited components suitable for such sets. Full particulars of the work of the Schools Radio Society can be obtained by those interested from the Hon. Secretary, Mr. R. J. Hibberd, St. Paul's School, Dorking.

A THIRD-CLASS PASSENGER LINER.

AN interesting departure in ocean travel has just been made by the Atlantic Transport Line, who have fitted up their ss. Minnekahda exclusively as a third-class passenger boat. This vessel, which is of 17,281 gross tonnage, was built by Messrs. Harland and Wolff in 1917, and reconditioned by the Bethlehem Shipbuilding Corporation in 1921. She is a triple-screw ship fitted with triple-expansion reciprocating engines and a low-pressure turbine, her length being 646 ft. There is accommodation for some 750 passengers, and as these will all be of the same class the entire steamer will be at their disposal. The passenger accommodation comprises well-equipped cabins for two, three or four persons, extensive promenade decks, smoking room, dining saloon, lounge and library. The vessel will be placed on the London-New York service, calling at Boulogne in both directions, the crossing being made in nine days. The extremely moderate return fare charged should open up the possibility of a visit to the States to numbers of people who have hitherto regarded the cost of such a venture as prohibitive.

HEAVY-DUTY WORM-DRIVE MILLING MACHINES.

THE two milling machines which we illustrate in Figs. 1 to 6, on pages 384 and 385, have been introduced by Messrs. James Archdale and Co., Limited, of Birmingham, for heavy-duty, and embody a number of interesting features. They can be supplied either as plain machines, with full-automatic control for the table feed, or with hand-operated quick power traverse alone, and in the latter case safety stops are provided to disengage the action at the extreme ends of the table feed. In the plain machine, an automatic feed engagement is provided, which enables the work to be quickly moved by hand to the cutter, and, at a predetermined distance from it, the feed is automatically engaged, thus preventing damage to cutters and eliminating waste of time due to idle feeding. An interesting feature of the machines is that the spindle drive is by worm and worm wheel of special design manufactured by the Lanchester Motor Company, Limited, of Birmingham, and identical with that employed in the final drive of the Lanchester car. This method of drive ensures steady cutting under the most difficult conditions.

Dealing with the single-head machine illustrated in Figs. 1 to 4 first, the drive is from the line shaft to fast and loose pulleys carried on a shaft running in the frame of the machine behind the headstock. These pulleys, with the adjustable belt shifter, can be seen in Figs. 1 and 2. The pulley shaft drives a

SINGLE-HEAD, HEAVY-DUTY, WORM-DRIVE MILLING MACHINE.

CONSTRUCTED BY MESSRS. JAMES ARCHDALE AND CO., LIMITED, ENGINEERS, BIRMINGHAM.

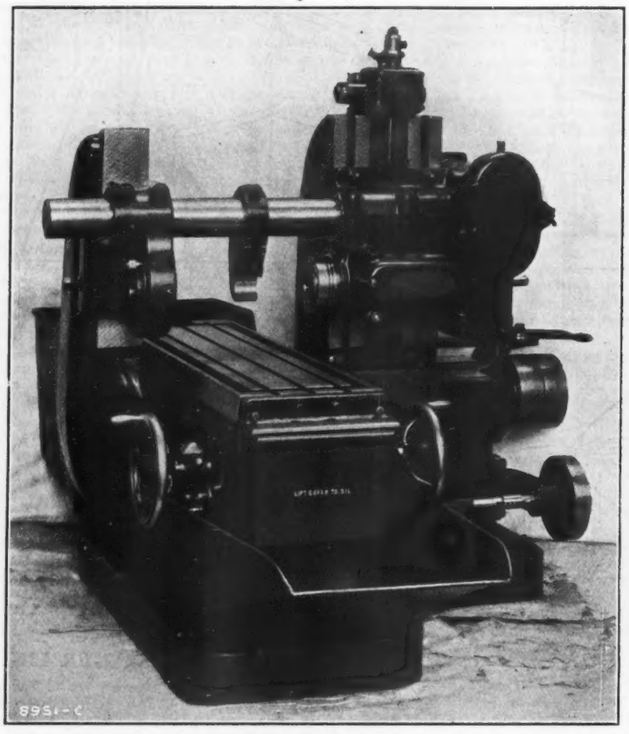


FIG. 1. VIEW FROM FRONT OF MACHINE.

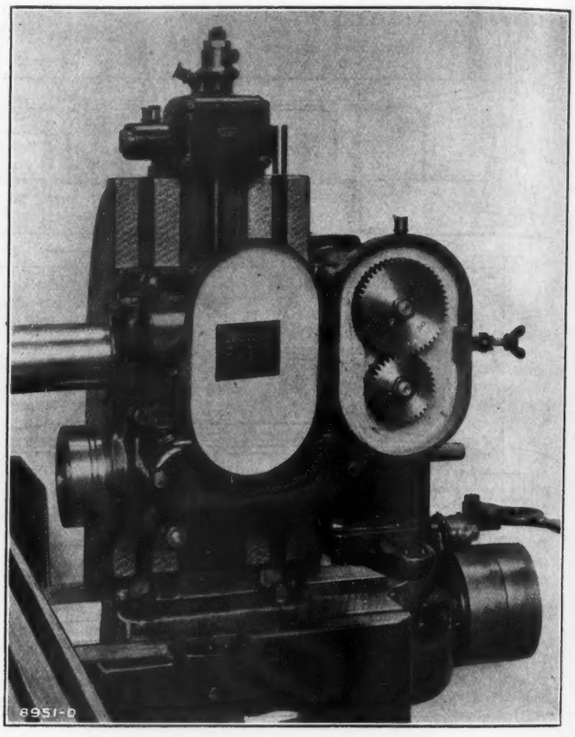


FIG. 2. HEADSTOCK AND SPINDLE GEAR BOX.

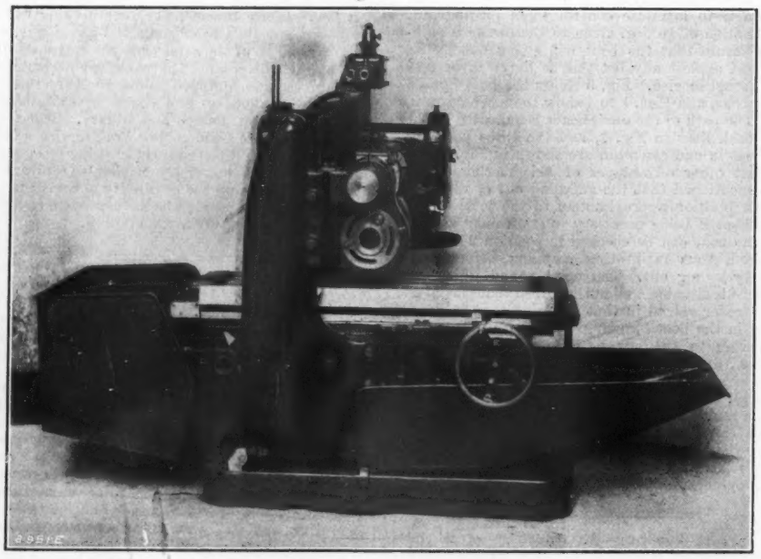


FIG. 3. SIDE VIEW OF MACHINE.

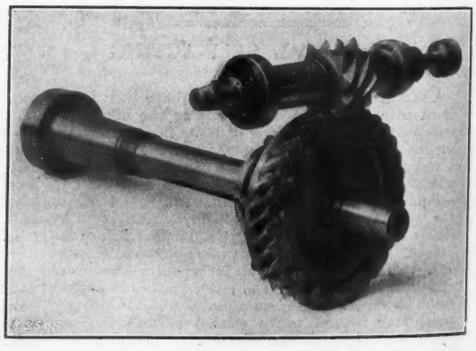


FIG. 4. WORM SHAFT AND SPINDLE.

vertical spindle, which can be seen projecting above the right-hand headstock slide in Fig. 2, by bevel gears, and this in turn drives the upper gear-wheel spindle seen in Fig. 2, through a second set of bevels. The lower gear wheel is carried on a worm shaft, and the worm on the latter engages with a large-diameter, phosphor-bronze worm wheel running in oil and mounted on the headstock spindle proper. The spindle is hardened and ground, and is provided with a conical bearing at the front end and heavy-duty ball bearing at the back. The spindle is hollow and is provided with a drawbolt for arbors. The end is formed with a box clutch, face mills being arranged to bolt direct to the face of the spindle. A protecting cap is fitted over the spindle nose to prevent grit entering the thrust surfaces. The worm shaft and spindle are shown separately in Fig. 4. The gear wheels shown in Fig. 2 are bored taper, and in addition are keyed, a locknut being provided to secure the gear on the shaft. A wheel drawer for removing these wheels is supplied with the machine. A second speed is provided by reversing the position of these wheels, and a pair of change wheels enables two additional speeds to be obtained, making four spindle speeds in all. The table is of ample proportions and slides directly in the bed of the machine, the usual middle slide being eliminated. For adjustment to take up wear, two separately-adjustable taper strips are provided, a feature making for the maintenance of alignment over long periods. The table-feed pulley, which can be clearly seen in Fig. 1, is driven by a belt from the main pulley shaft on the machine. From the feed-pulley shaft, the table drive is taken through a change-gear box with removable gears similar to the spindle-feed box, and thence to the table feed and traverse motion. This box is not visible in the illustrations as it is mounted on the right-hand side of the table as seen in Fig. 1. Two pairs of gears are provided, giving four rates of power feed, and standard gears are obtainable to give any rate of feed within a range of from 0·9 inch to 12·6 inches per minute. The headstock column is adjustable horizontally along the bed, as can be seen in Figs. 1 and 2, and is locked by bolts visible in the latter figure. A micrometer dial is provided to facilitate the adjustment. The

DUPLEX-HEAD, WORM-DRIVE MILLING MACHINE.

CONSTRUCTED BY MESSRS. JAMES ARCHDALE AND CO., LIMITED, BIRMINGHAM.

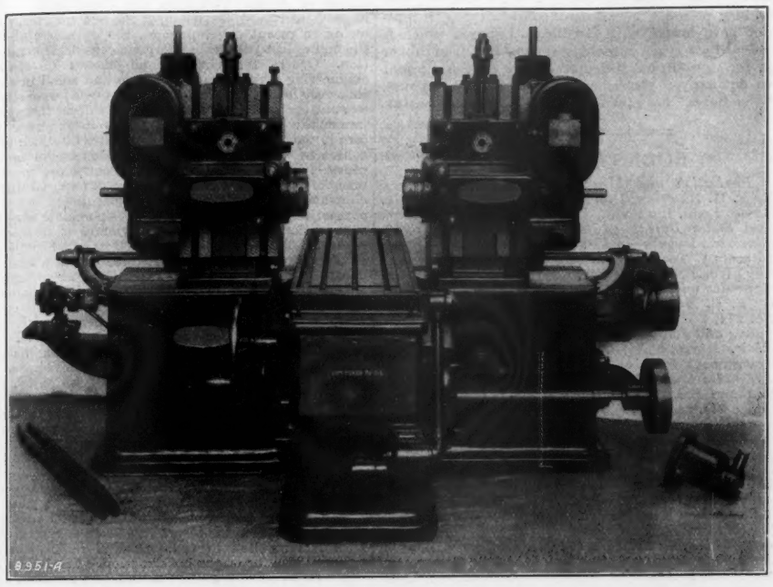


FIG. 5. VIEW FROM FRONT OF MACHINE.

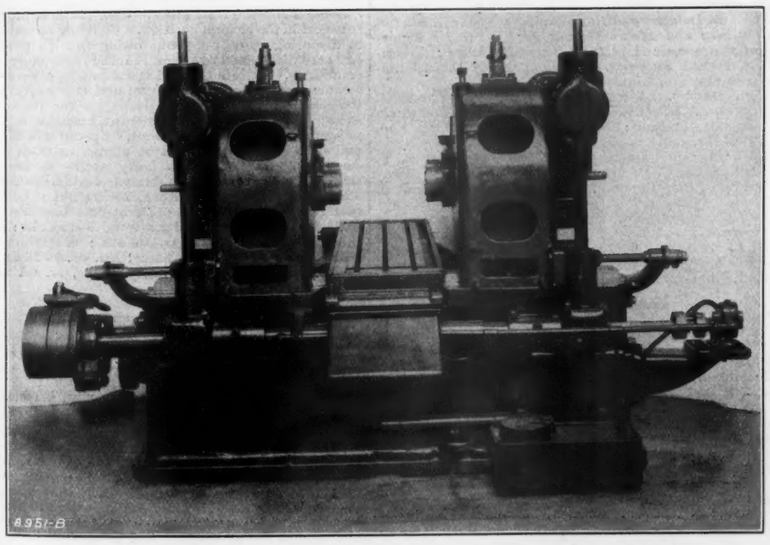


FIG. 6. VIEW FROM REAR OF MACHINE.

headstock is adjustable vertically by means of the screwed spindle seen in the same figures, a micrometer dial being also provided in this case. The slides are fixed rigidly to the uprights by four bolts and are provided with taper gibs for taking up wear. The tailstock is moved simultaneously with the spindle head, the two being connected by an overarm of large diameter. An adjustable phosphor-bronze bearing for supporting the arbor end is fitted in a bush, which can be easily removed from the hole in the tailstock, leaving a clear space for removing cutters and arbors complete. The cutters can therefore be changed quickly without removing the tailstock and bracket. The central arbor support, seen in Fig. 1, may be swung clear when changing cutters. A felt wiper is fitted which lubricates the bearing and keeps it free from chips. Adequate splash guards are fitted which can be seen in Figs. 1 and 3.

The general arrangement of the duplex-head machine, shown in Figs. 5 and 6, is generally similar to that of the single-head machine, and it is, therefore, not necessary to describe it in detail. The machine, in this case, is arranged for slab or face milling, means being provided to reverse the direction of spindle rotation. To provide support when the machine is required for slab milling, a removable arbor steady, shown at the bottom right-hand corner of Fig. 5, is provided. This steady is bolted to the front of one of the heads. Provision is made for connecting the two heads when heavy face milling is to be performed. As in the case of the single-head type, this tool can be supplied either as a plain machine, with hand-controlled quick power traverse for the table, or as a full automatic. Either machine can be supplied for motor drive if desired.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Minutes of Proceedings No. 13, of this Institution, just issued, contain reprints of a paper by Commander F. L. M. Boothby, on "Commercial Airship Design," and one by Col. N. T. Belaiew, entitled "Steel *versus* Lighter Alloys"; the discussions on both of these papers which were read at the meetings held on October 17 and November 7 last, respectively, are also given. The Minutes are obtainable from the Offices of the Institution at 60, Chancery Lane, London, W.C.2., price 1*s.* 6*d.*

LETTER TO THE EDITOR.

GUNNERY AT THE BATTLE OF JUTLAND.

TO THE EDITOR OF ENGINEERING.

SIR,—The review (page 253 *ante*) of Admiral Bacon's book, "The Jutland Scandal," refers to the quality of the gunnery of the British ships. It is generally assumed that German gunnery at Jutland was excellent, while that of the British—especially that of the battle-cruisers—was poor. Such a conclusion will inevitably be arrived at unless the visibility conditions are accurately studied. The loss of Indefatigable and Invincible, and the narrow escape of Lion, are to be attributed to faulty construction. In each case the damage resulted from single chance shots striking turrets (eye-witnesses' reports) and flashing off the magazines *via* the cordite train from gun-house to magazine. German ships, when similarly hit, in no case blew up. It is a simple matter to render magazines flash-tight, but British constructors neglected to do this, and hence the destruction of, and damage to, certain capital ships is to be attributed to faulty construction in one very vital respect.

It is most probable that Queen Mary went from the same cause—such is the opinion of one of the few survivors.

It is certainly true that, in the first phase of the action, the German ships hit oftener than they were hit; but there is a very real reason for this, viz., that the visibility east to west was so vastly superior to that west to east that, for all practical purposes, the British ships were out of action. The key to the visibility conditions at Jutland is to be found in Von Hase's book, for he gives information which enables one to assign to "visibility" not merely a relative but an absolute value, which one may illustrate as follows from personal experience. When out for a shoot off Start Bay we had to close to 3,500 to see the target to the east of us, as a strong east wind was raising a vertical misty haze. To the west one could see "flies crawling up the Start Light" at 10 miles. Assuming our target was firing back at us, we should not have had a dog's chance unless the target's gunnery was, to put it mildly, rotten. At Jutland, the German battle-cruisers picked up our battle-cruisers 12 minutes before we could see them—not a bad commencement. How conditions appeared from west to east is fully indicated in the logs of the various ships, from which one could quote *ad nauseam*. But let us read what Von Hase has to say ("*Kiel and Jutland*"):—

P. 96: "The determining elements for the value of a position are the direction of the wind, sun, the amount of sea, and visibility."

P. 97: "Lastly, visibility and light may be of paramount importance, as these may vary so greatly in different quarters that it may happen that we can easily see the enemy ship, ourselves being concealed as completely from the enemy as if we were shrouded by the hood of invisibility."

P. 101: "Thus, even during the Skagerrak battle, the superior speed of the English enabled them to convert what was for them a bad position from the point of view of wind into a good one, which also gave them the pull from the point of view of light."

P. 149: "What astonished me was that so far we had only been hit once. Only quite rarely did a shot stray near us. I observed the gun turrets of our target more closely, and established that this ship was not firing at us. . . . By some mistake we were being left out. I laughed grimly now, and I began to engage our enemy with complete calm as at gun practice."

P. 150: "I again fixed the gun turrets of our enemy and watched them carefully. I now saw they were directly trained on us."

P. 152: "Sixteen kilometres is indeed a very respectable range, but actually the good visibility and spotting conditions made it appear small. The Zeiss lenses of our periscopes were excellent. At the longest distances I could make out all details of the enemy ships, as, for instance, all movements of turrets and individual guns."

P. 153: "The north-west wind was blowing the smoke from the English guns between them and us. As a result of this, their view was often hampered and shooting made difficult."

P. 174: It was not long before gunnery conditions underwent a fundamental change."

P. 177: "The visibility was now so bad that it was difficult for us to distinguish the enemy ships. . . . At 6.15 we came under a heavy fire. We could only make out the ships' hulls indistinctly (in spite of excellent Zeiss lenses J.N.R.P.), but, as far as I was able to see the horizon, enemy ships were all round us. . . . I was unable to engage the second from the right, but selected the one I could see best."

P. 181: "At 6.24 I began to engage large enemy battleships to the north-east. Even though the ranges were short, from 6,000 to 7,000 m., the ships often

became invisible in the slowly advancing mists mixed with the smoke from guns and funnels. It was almost impossible to observe the splashes. . . . Meanwhile we were being subjected to a heavy, accurate, and rapid fire from several ships at the same time. It was clear that the enemy could now see us much better than we could see him . . . This will be difficult to understand for anyone who does not know the sea. . . . This went on till 6.29. At this moment the veil of mist in front of us split across like the curtain at a theatre. Clear and sharply silhouetted against the uncovered part of the horizon, we saw a powerful battleship. . . ." The destruction of Invincible followed. A single shot into her forward turret and she went up.

P. 197: "And all this time we were steaming at full speed into this inferno, offering a splendid target to the enemy, while they were still hard to make out."

P. 201: "All we could see was the great reddish-gold flames spurting from the guns. The ship's hulls we saw but rarely. . . . Without much hope of hurting the enemy, I ordered the two forward turrets to fire salvo after salvo."

To Von Hase's observations one may add two from Scheer's report:—

"The decrease of fire at the head of the line was only due to the setting sun making it more and more difficult, and finally practically impossible, to range and spot."

"These ships suffered very severely, as they were able to distinguish little more of the enemy than the flashes of his salvoes, whereas they themselves apparently offered good targets."

With this information at the disposal of the British public for some years, it seems to me surprising that people should yet speak of "poor British gunnery" at Jutland.

Considering the very excellent gunnery conditions which the Germans had during the first phase of the action, one is justified in concluding that had German gunnery been even average, not a single British battle-cruiser should have got away. Now the visibility conditions are accurately known, it seems evident that, not only was German gunnery not superior to British, but was considerably inferior.

J. L. R. PASTFIELD.

The Parsonage, Stornoway, March 10.

GAS MASKS FOR PETROLEUM VAPOURS.

CANISTER gas masks are now used at one at least of the United States oil refineries by the men engaged in filling tank cars. The cars, containing at times a little residual gasoline, arrive with the top manholes and the bottom drain pipes open; before the tanks are filled, men enter to inspect them, and this operation may take three minutes. The canisters used in this work last several weeks. Such precautions, however, are not often taken, according to Technical Paper No. 348 of the U.S. Bureau of Mines, on "Gas Masks for Petroleum Vapours," drawn up by S. H. Katz and J. J. Bloomfield, though even fatal cases of vapour poisoning occur in oil refineries, dry-cleaning establishments, rubber factories, &c. Gas masks are not popular for various reasons. The masks are cumbersome and expensive, cannot be put on and off rapidly, and afford, after all, only a limited protection. The ordinary canister type of gas mask, charged with 600 cub. cm. of dry activated charcoal, protects the wearer for an hour or more in air containing 1 per cent. of gasoline, but otherwise normal. Moisture reduces the capacity of the charcoal, and it is not safe to use the canister in air contaminated with more than 2 per cent. of gasoline, although in distillation tanks the air may, of course, be saturated with gasoline. The charcoal can be revived by drawing air at 105 deg. C. through it for two hours. Some petroleum also contains hydrogen sulphide, which is the more deadly a poison because only traces of it are betrayed by its smell, whilst the more concentrated gas paralyses the olfactory nerves. Charcoal canisters will only protect against 1 per cent. of hydrogen sulphide for 3½ minutes. Soda-lime canisters afford a better protection against this gas than charcoal, and also adsorb chlorine, phosgene and sulphur dioxide; but soda-lime cannot be regenerated, and it is useless against ammonia, gasoline and other organic vapours. Gas canisters containing 3,000 cub. cm. of charcoal, or mixtures of charcoal and soda-lime offer certain advantages; but they are not safe in highly-poisonous atmospheres, and the wearer does not know what concentration he may have to face.

In general, respirators which supply the wearer with fresh air or oxygen are preferable to gas masks, as long as the atmosphere is not too corrosive for the skin. The Bureau has tested respirators of two types. The hose-mask is a gas mask to which a flexible rubber pipe, about 1 in. in diameter and stiffened by a wire spiral, is attached and supported by a belt. The hose may be 150 ft. long, but breathing becomes more difficult as the length increases, and a rotary blower is then needed at the pure-air end of the hose. This necessitates an extra man, but greater safety is also secured. The hose requires no chemicals, can be cleaned by the occasional use of a blower and will last for a long period. The Bureau combines the Kopps-Tissot hose masks with its McCaa harness, which is also used for oxygen-breathing apparatus. The rubber bags for oxygen on the market up to the present have not proved impermeable to petroleum vapours, but the Bureau has now designed a suitable apparatus.

BOOKS RECEIVED.

The Production and Measurement of Low Pressures. By F. H. NEWMAN, D.Sc., D.I.C., F.Inst.P. London: Ernest Benn, Limited. [Price 16*s.* net.]

United States Bureau of Standards. Circular No. 19. *Standard Density and Volumetric Tables.* [Price 15 cents.] Technologic Papers, No. 268, *A Study of Silk Waste used for Cartridge-Bag Cloth, with an Appendix on the General Classification of Waste Silk.* By F. R. MCGOWAN and OTHERS. [Price 15 cents.] No. 274, *Use of United States Government Specification Paints and Paint Materials.* By P. H. Walker and E. F. Hickman. [Price 10 cents.] Washington: Government Printing Office.

The Empire Commercial Guide and Empire Year-Book. London: British Commonwealth Trade Press, Limited. [Price 21*s.* net.]

Sewage Disposal in India and the East: A Manual of the Latest Practice applied to Tropical Conditions. By G. BRANSBY WILLIAMS, M.Inst.C.E., M.I.Mech.E. Calcutta and Simla: Thacker Spink and Co. [Price Rs. 10,8.]

Taschenbuch der Luftflotten, 1924-25. Edited by DR. ING. WERNER VON LANGSDORFF. Munich: J. F. Lehmanns. [Price 12 marks.]

Transactions of the First World Power Conference, London, June 30 to July 12, 1924. Vol. I., *Power Resources of the World; Available and Utilised.* Vol. II., *Water Power Production; Preparation of Fuels; Steam Power Production;* Vol. III., *Internal-Combustion Engines; Gas and Fuel Section; Power from other Sources; Power Transmission and Distribution; Standardisation and Research, Illumination.* Vol. IV., *Power in Industry and Domestic Use; Power in Electro-Chemistry and Electro-Metallurgy; Power for Transport; Economic Aspects of Power Resources; Education, Health, Publicity.* London: Percy Lund Humphries and Co., Limited. [Price 10*l.* net.]

Pattern Making. A Practical Treatise. By JOSEPH G. HORNER, A.M.I.M.E. Fifth edition, revised and much enlarged. London: Crosby Lockwood and Son. [Price 18*s.* net.]

Machine Design. Questions and Problems. By E. F. GARNER and C. D. ALBERT. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 7*s.* 6*d.* net.]

Public Works Supplies. Requirements, Resources and the Construction of Works. By F. E. TURNEAURE and H. L. RUSSELL. Third edition, revised. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 30*s.* net.]

PERSONAL.—Messrs. G. M. Clark and Partner have opened offices at 7, Victoria Street, S.W.1., where they will act as consulting engineers. The firm has done much important work in South Africa, and Mr. G. M. Clark, M.Inst.C.E., acted as South African Member of Council of the Institution of Civil Engineers for three years. Mr. G. J. Moore, M.I.Mech.E., M.I.E.E., Mr. Clark's partner, will remain in Johannesburg at 40, Meischke's Building. Mr. W. Parker, M.Inc.C.E., who was for many years works manager at Siemens Stafford Works, will be in charge of the London office.—Mr. R. W. Weekes, consulting engineer, of Maxwell House, Arundel-street, Strand, London, W.C.2, has announced that he has disposed of his practice to Mr. W. J. Hudson, who, for a number of years has been associated with him in the carrying out of works. The practice will, in future, be carried on under the name of Messrs. Weekes and Hudson from the same address.—W. T. Henley's Telegraph Works Company, Limited, of Bloomfield-street, London, E.C.2, have removed their head office and London warehouse to 11, Holborn-viaduct, London, E.C.1.—We are requested by Messrs. Andrew Barclay, Sons and Co., Limited, Caledonia Works, Kilmarnock, the well-known locomotive builders, to state that there is no connection between them and the firm of Messrs. Barclay and Co., Limited, also of Kilmarnock, but whose address is John Finnie-street.—It is announced that the address of the London Office of The Staveley Coal and Iron Company, Limited, is now Crown House, Aldwych, W.C.2, not 34, Victoria-street, Westminster, S.W.1, as formerly.—We have been notified that the business which until recently was carried on by the late Mr. S. Utting at Grosvenor Mansions, 82, Victoria-street, London, S.W.1, has now been taken over by the French principals, Société des Cheminées Louis Prat (S.A.), Paris, and is now registered under the name of the Prat Draught Company at the above address.—The offices of the International Railway Congress Association, until recently at 17, Rue de Louvain, have been transferred to 74, Rue de Progrès, Brussels.—Messrs. Cox and Danks, Limited, iron and steel merchants and salvage contractors, have removed from Arcade Chambers, Manchester, to more commodious premises at Parsonage Chambers, 3, The Parsonage, Manchester.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Consistent with the conditions experienced throughout, the quarter is ending very unsatisfactorily so far as the heavy steel and engineering trades of South Yorkshire are concerned. Hope of improvement now centres upon the new quarter, though, owing to recent developments, the optimism shown at the end of last year has undergone considerable modification. Orders for virtually all classes of steel and engineering products are so scarce and small in tonnage that very few works are prepared to buy a larger supply of raw and semi-finished materials than will see them through immediate requirements. Business in pig-iron is uniformly flat, despite the attractive rates at which forward contracts can be undertaken. Depression similarly prevails in basic steel. Local furnaces are getting an unsatisfactory share of the amount of export business in circulation, being repeatedly underquoted by foreign competitors. Bar iron makers are up against very strong competition from Belgium. Germany is underquoting substantially for cold-rolled steel strip. Production of wire rods has also been restricted to meet a diminished demand. Supplies of iron and steel scrap are going chiefly to foreign buyers, French and German agents figuring as the main purchasers. Machinery cast-iron scrap is offered at 92*s.* 6*d.* to 95*s.* per ton delivered at West Riding stations. Holders are asking 77*s.* 6*d.* per ton delivered at works for heavy melting basic-steel scrap, but there are few local buyers at this figure. Steel turnings for basic furnaces are quoted at 62*s.* 6*d.* per ton delivered, and builders' light cast-iron scrap for basic, at 72*s.* 6*d.* per ton delivered. A temporary run on acid-steel scrap caused prices to rise to 5*l.* 15*s.* per ton, but a recent contraction in purchases has resulted in the average market quotation being reduced to 5*l.* 7*s.* 6*d.* The amount of work in hand at concerns producing heavy forgings and castings is nothing like sufficient to enable plant to operate economically. Producers find themselves severely underquoted by Continental competitors, despite their sacrifice of profit. The cheapness of basic steel has resulted in that material largely displacing wrought iron for wagon construction. The lighter trades continue to occupy a more satisfactory position, as compared with the heavy industries, from the standpoint of actual production, but for many classes of tools, which are leaving Sheffield in fair quantities, the prices ruling leave only a microscopic margin for profit.

South Yorkshire Coal Trade.—There is no improvement to report in the general position. Collieries have difficulty in disposing of outputs, but owing to high production costs are disinclined to accept reduced rates under current conditions. Efforts to stem the slump in export of best steams seem doomed to failure, and it is expected that the next official returns of traffic *via* the Humber will show further reaction. Moderate business is passing in best steams on home account. Special lots of cobbles and nuts are being offered at attractive rates to clear surpluses. House coal is fairly active at unchanged rates. Quotations:—Best branch handpicked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 31*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 20*s.* to 24*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.*; smalls, 4*s.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Scarcity of Cleveland pig-iron is enabling producers to take a firmer stand. They report fairly good sales, and have advanced their quotations 6d. per ton. Messrs. Cochrane and Co. have intimated their intention of putting another blast-furnace out of operation, which would leave the firm with only one blowing. Their action is attributed to continued unremunerative quotations. Now that the market has at length taken an upward turn, buyers who have been holding orders up are expected to come forward. Makers have resumed the practice of asking rather more for export than for home consumption, and they report rather better inquiry from abroad. No. 1 Cleveland pig is 83*s.*; No. 3 g.m.b., 78*s.*; No. 4 foundry, 77*s.*; and No. 4 forge, 76*s.*

Hematite.—East-Coast hematite is plentiful, producers still carrying considerable stocks, but some firms are less inclined to make price concessions than they have been. In this branch also there is some little improvement in inquiry for export. Quotations are irregular, Nos. 1, 2 and 3 varying from 83*s.* 6*d.* to 84*s.* 6*d.*

Foreign Ore.—Imported ore is as difficult as ever to dispose of, and, in the absence of business, quotations are nominal on the basis of best rubio at 22*s.* c.i.f. Tees.

Blast-Furnace Coke.—Durham blast-furnace coke is in very ample supply, and is easy in price. Good average qualities are obtainable at 23*s.*, delivered to consumers here.

Manufactured Iron and Steel.—Finished iron and steel producers are short of work, and are keen to book orders. In one or two branches inquiries are a little better. Some inquiries for steel for Italy, however, do not appear likely to result in sales, owing to the heavy import duty to that country. Quotations show no movement. For shipment, less than the following recognised home quotations are accepted:—Common iron bars, 12*l.*;

iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* 5*s.*; steel angles, 9*l.*; steel joists, 9*l.*; heavy steel rails, 9*l.* to 9*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge), 16*l.* 10*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The serious depression prevailing in the Welsh coal trade is further testified by the fact that the Blaenavon Company has given notice to 2,500 miners because of unremunerative trading conditions. Not only will the Blaenavon pits be rendered idle but also the steelworks, and it is estimated that some 15,000 people will suffer in consequence of the closing of these pits. Other smaller concerns are also shutting down, while the majority of the collieries working in the coalfield are only able to keep going on an average from four to five and a-half days a week. During the week, the Great Southern Railway of Ireland placed contracts with two well-known Cardiff export firms for 120,000 tons of Cardiff and Monmouthshire large coal for delivery over the next six months. It is also announced that Cardiff firms have submitted the lowest c.i.f. tenders in respect of the Egyptian State Railways' requirements of 150,000 metric tons of large coal delivered at Alexandria over May, June and July. One firm offers to supply the coal at 34*s.* 4*d.*, and another at 34*s.* 6*d.*, which, at the current freight of 11*s.* 6*d.* Alexandria, would leave 22*s.* 6*d.* to 22*s.* 8*d.* f.o.b. for the coal. It may be stated that the running contract which expires in May is held at 34*s.* 11*d.* c.i.f. for 150,000 metric tons, and at 34*s.* 8½*d.* for 50,000 tons, or 5*d.* and 4½d. per ton above the prices now quoted. Definite news of the placing of the business is not expected until the beginning of next week. The Norwegian State Railways are in the market for 110,000 tons of large over twelve months, but for the first time tenders are invited outside the United Kingdom, prices being asked from Germany and Spitzbergen. The Latvian State Railways also want prices for 30,000 tons of large coal. Best admiralty large rules from 26*s.* to 27*s.* with Monmouthshire large from 22*s.* 6*d.* to 24*s.* 6*d.* and dry large 23*s.* 6*d.* to 25*s.* 6*d.* Best steam smalls range from 15*s.* to 16*s.*

Further Decline in Trade.—There was a further diminution in the volume of the coal fuel and coke trade in February shipments from the South Wales ports, totalling only 2,363,969 tons compared with 2,487,327 tons in January, a decrease of 123,358 tons. Foreign cargo shipments of coal were lowered by 88,056 tons, bunker exports by 26,111 tons and the coastwise cargo trade by 12,725 tons. Shipments of coke were also reduced by 1,785 tons, but those of patent fuel were increased by 5,319 tons. The returns were as follows :—

	January. Tons.	February. Tons.
Coal—		
Foreign (cargo) ...	1,928,856	1,840,800
,, (bunkers) ...	334,699	308,588
Coastwise (cargo) ...	120,127	107,402
Totals ...	2,383,682	2,256,790
Fuel (foreign)	96,089	101,408
Coke (,,)	7,556	5,771
Grand totals ...	2,487,327	2,363,969

Imports of pitwood and pitprops in February totalled 133,160 loads against 168,323 loads in January, and that of iron ore 109,205 tons compared with 151,296 tons.

THE LATE MR. JAMES ARCHDALE.—One of the pioneers of the British machine tool industry, Mr. James Archdale, died on Sunday last at his residence, The Yews, Harborne, at the advanced age of 86 years. Born at Leeds, he received his early engineering training in the north of England, but left this part of the country to join the firm of Tangyes, Limited, at Birmingham, in 1861. After experience with this firm, he started on his own account as a machine-tool maker, and the business was formed into a limited-liability company, under the title of James Archdale and Co., Limited, in 1902. Mr. Archdale took an interest in the activities of the firm up to the time of his death, when he was Chairman of the Company. He leaves a widow and four sons, three of whom are with the firm founded by their father, and the fourth with Messrs. Gibson Battle and Co. (Melbourne), Pty., Limited.

THE LATE MR. JOHN R. BILLINGTON.—We regret to record the death, which took place on Sunday, March 22, of Mr. John Robert Billington, technical assistant on the engineering staff of the London, Midland and Scottish Railway Company. The deceased gentleman, who was born in 1873, served his apprenticeship at Horwich Works. In October, 1894, he was transferred to the drawing office, and seven years later was placed in charge of the department for the physical testing of materials. Appointed manager of the Gas Department of the old Lancashire and Yorkshire Railway in 1904, Mr. Billington retained this post until the grouping of the railways some few years ago. As representative of the London, Midland and Scottish Railway Company, he attended investigations carried out in connection with mechanical and electrical railway traction abroad. An associate member of the Institutions of Civil Engineers and Electrical Engineers, and a member of the Institution of Mechanical Engineers, Mr. Billington proved as keen a student at Horwich Railway Mechanics' Institute in his younger days—he was a Whitworth Exhibitioner in 1897—as he was a member of the Management Committee in later years. He was 51 years of age.

NOTICES OF MEETINGS.

THE SOCIETY OF CHEMICAL INDUSTRY : CHEMICAL ENGINEERING GROUP.—To-night, at 5 p.m., at the Chemical Society, Burlington House, Piccadilly, W. 1. "Crushers used in the Chemical Industry," by Mr. William T. W. Miller. "Notes on Coal Crushing and Grinding Machinery," by Mr. R. J. Glinn. "The Raymond System of Grinding and Air Separation," by Mr. C. S. Messinger, B.A. "Grinding Mills, with Special Reference to Rollers," by Mr. C. J. Seaman, M.I.Mech.E.

THE INSTITUTE OF MARINE ENGINEERS.—To-night, at 6.30 p.m., at 85–88, The Minories, Tower Hill, E. 1. Annual Meeting.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night, at 7 p.m., at Storey's Gate, S.W. 1. Informal Meeting. Discussion on "The Cutting of Heavy Steel Sections." Monday, March 30, at 7 p.m. Graduates' Meeting. Informal discussion on "Road *v.* Rail Transport." Friday, April 3, at 7 p.m. Informal Meeting. Discussion on "Modern Developments of Gas Production."

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Ordinary Meeting. "Modern Transport," by Mr. S. H. Hole. Friday, March 27, at 7.30 p.m. Lecturette : "Irrigation Engineering in Burma," by Mr. A. P. Morris.

THE INSTITUTION OF ENGINEERING INSPECTION.—To-night, at 7.45 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Informal Meeting. General discussion on "Remuneration for Inspection Work whether paid by Fees or by Salary."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—To-night, at 9 p.m., at Albemarle-street, W. 1. "Studies of Atomic Nuclei," by Sir Ernest Rutherford. Thursday, April 2, at 5.15 p.m. "Chemical and Physical Effects of Light" (Lecture II), by Mr. T. Thorne Baker.

THE MIDLAND INSTITUTE OF MINING ENGINEERS.—Saturday, March 28, at 2.15 p.m., at the Danum Hotel, Doncaster. "Notes on Devices to Prevent Overwinding," by Professor J. A. S. Ritson and Mr. W. L. Grassham, B.Sc. "Mines (Working Facilities and Support) Act, Part I, 1923," by Mr. J. H. Cockburn. "Manufacture of Coke-Oven Coke," by Dr. E. W. Smith and Mr. F. S. Townend, B.Sc.

THE INSTITUTION OF CIVIL ENGINEERS : NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, March 30, at 7.30 p.m. "Roads : Their Maintenance, Administration and Finance," by Mr. A. E. Brookes, M.Inst.C.E.

THE BRADFORD ENGINEERING SOCIETY.—Monday, March 30, at 7.30 p.m., at the Bradford Technical College. Lecture : "Some Problems in Engine Governing, with Special Reference to the 'Veloscope' Variable-Speed Governor," by Mr. M. Carter, B.Sc.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 31, at 6 p.m., at Great George-street, S.W. 1. Ordinary Meeting. Paper to be further discussed : "The Large Water-Tube Boiler," by Mr. Philip Warwick Robson, M.Inst.C.E. Wednesday, April 1, at 6 p.m. Students' Meeting. "The Evolution and Construction of Modern Arterial Roads in England," by Mr. John Cyril Hargreaves, M.Eng.

THE SIR JOHN CASS METALLURGICAL SOCIETY.—Tuesday, March 31, at 8 p.m., at the Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C. 3. "Gold and Silver Mining in Ontario," by Mr. W. C. Noxon.

THE INSTITUTION OF NAVAL ARCHITECTS.—Annual General Meeting. Wednesday, April 1, to Friday, April 3, at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Wednesday, April 1, at 11 a.m. Address by the President, His Grace the Duke of Northumberland, M.V.O. Papers to be read and discussed. "Relative Commercial Efficiency of Internal-Combustion and Steam Engines for High-Speed Passenger Vessels," by Sir John H. Biles, K.C.I.E., LL.D., D.Sc. "Japan's Contribution to Naval Architecture," by Professor F. P. Purvis. "Analysis of Professor Sir John Biles's Paper on H.M.S. Wolf Experiments," by Mr. G. H. Hoffmann. At 7.30 p.m. Annual Dinner in the Grand Hall, Connaught Rooms, Great Queen-street, W.C. 2. Thursday, April 2, at 11 a.m. "Wake Propeller Coefficients," by Admiral D. W. Taylor, U.S.N. "Form Effects and Form Resistance of Ships," by Mr. W. G. A. Perring. "A Suggested Method of Increasing the Efficiency of the Screw Propeller," by Mr. Walter Pollock. At 3 p.m. "Stresses in Rectangular Plates Clamped at their Edges and Loaded with a Uniformly Distributed Pressure," by Professor C. E. Inglis, M.A. "Notes on the Rolling of Ships," by Mr. G. Vedeler, M.Sc. "Model Experiments with Anti-Rolling Tanks," by Mr. H. J. R. Biles, B.Sc. At 8 p.m. Second Report of the Marine Oil-Engine Trials Committee. Friday, April 3, at 11 a.m. "Tonnage Legislation and its Application to the Measurement of Ships," by Mr. E. W. Blocksidge. "Influence of Trading Conditions on the Design of Intermediate Passenger Vessels," by Mr. W. G. Cleghorn. "Stability and Seaworthiness," by Mr. C. Frodsham Holt. At 3 p.m. "The Propulsive Performance of the Corrugated Ship," by Mr. A. H. Haver and Mr. E. V. Telfer, M.Sc., Ph.D.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Wednesday, April 1, at 6 p.m., at Savoy Place, Victoria-embankment, W.C.2. (Wireless Section), "The Leafield Coupled Arc," by Major A. G. Lee, B.Sc., and Mr. A. J. Gill, B.Sc. Thursday, April 2, at 6 p.m. (Ordinary Meeting). General Discussion on Electricity Supply Tariffs, with Introductory Paper by Mr. H. M. Sayers. "Electricity Supply Tariffs : Their Simplification by Discrimination," by Mr. G. Wilkinson and Mr. R. McCourt.

THE ROYAL SOCIETY OF ARTS.—Wednesday, April 1, at 8 p.m., at John-street, Adelphi, W.C.2. "Siam : Its Progress and Possibilities," by Mr. William Nunn.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, April 1, at 8 p.m., at the Society's Rooms, The Temple, Dale-street, Liverpool. "The Salving of S.S. Bardic," by Commander Ivo J. Kay, R.D., R.N.R.

THE INSTITUTION OF MECHANICAL ENGINEERS : NORTH-WESTERN BRANCH.—Thursday, April 2, at 7 p.m., at the Engineers' Club, Albert-square, Manchester. Lecture : "Swiss Federal Railway Electrification," by Mr. E. A. Eborall.

THE INSTITUTION OF MECHANICAL ENGINEERS : YORKSHIRE BRANCH.—Friday, April 3, at 7.30 p.m., at the Philosophical Hall, Park Row, Leeds. "The Accurate Measurement of Liquid Flow," by Mr. H. W. Swift.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the Scottish steel trade are no better this week, and business is of a very hand-to-mouth description. In most cases, buyers are not in a position to place much business, and, in consequence, orders are of small tonnage and mainly for immediate requirements. Producers are not receiving specifications with any regularity whatever, and deliveries of plates and sections are very far from keeping more than a part of the plant in operation. Inquiries, too, are of small moment. The announcement that the Australian Government has decided to favour the Clyde with orders for two cruisers, referred to below, has been received with much satisfaction, as many local industries will benefit from the circulation of money. In the black-sheet trade, a fair amount of business is passing, but the heavier gauges are not participating to any extent in the activity which prevails. Light sheets are well booked forward, and so also are the galvanised sorts, although fresh business is perhaps not just so plentiful as during the past month or two. Prices are keeping steady, and are as follow :—Boiler plates, 13*l.* per ton ; ship plates, 9*l.* 15*s.* per ton ; sections, 9*l.* 10*s.* per ton ; and sheets, ⅛ to ½ in., 11*l.* per ton, all delivered Glasgow stations.

Malleable-Iron Trade.—No change of any description has taken place in the West of Scotland malleable-iron trade over the week, and employment at the various works is as bad as ever. Not only is the home trade bad, but the demand from abroad is also exceedingly poor. In the steel re-rolling branches there is a certain amount of quietness and little continuity in the demand. The price of Crown bars is unchanged at 12*l.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—The demand for Scottish pig-iron continued to be of a very limited nature, both on home and export account. Buyers are not specifying for any tonnage of note, and a large percentage of the current output is going into stock. The general inquiry is not encouraging, and the outlook, on the whole, is not good. Hematite iron is unchanged in price, but foundry grades are quoted easier. The following are to-day's quotations :—Hematite, 4*l.* 11*s.* 6*d.* per ton, delivered at the steel works ; foundry iron, No. 1, 4*l.* 10*s.* 6*d.* per ton ; and No. 3, 4*l.* 8*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ended last Saturday, March 21, amounted to 594 tons. Of the total, 419 tons went foreign and 175 tons coastwise. For the corresponding week of last year the total shipments amounted to 1,111 tons.

Shipbuilding.—Telegraphic information to hand states that the Australian Commonwealth Government has decided to give Messrs. John Brown and Co. (Limited), Clydebank, the contract for the two 10,000-ton cruisers included in the naval-defence programme. The cost of the vessels, fully equipped and ready for sea, with spare parts, will be approximately 4,250,000*l.* This news has been well received here, and official confirmation is anxiously awaited. Another Clyde firm—Messrs. Lithgow (Limited), Port Glasgow, has received a contract for four cargo steamers, each of 7,000 tons deadweight-carrying capacity. These vessels are for Mr. James Russell, coal exporter and shipbroker, Glasgow. Messrs. Rankin and Blackmore (Limited), Greenock, will supply the vessels with triple-expansion reciprocating engines.

The Institution of Engineers and Shipbuilders in Scotland.—At a meeting of the Institution of Engineers and Shipbuilders in Scotland held in Glasgow last night (Tuesday), the following nominations were made for next session :—President, Mr. A. J. Campbell, general manager of Messrs. William Beardmore and Co.'s Dalmuir works ; vice-presidents, Mr. James Brown, C.B.E., Messrs. Scott's Shipbuilding and Engineering Company, Greenock ; Professor Percy A. Hillhouse, D.Sc., Glasgow University ; Mr. R. B. Mitchel, Glasgow Corporation electrical engineer ; and Lord Weir of Eastwood, of Messrs. G. and J. Weir, Glasgow. These nominations represent the number of vacancies, but the nominations for the members of council exceed the vacancies, and the names will be balloted on at a later date.

PHYSICAL SOCIETY OF LONDON.—At the meeting of this Society held in the Imperial College of Science, on February 27, the President, Mr. F. E. Smith, presented the Duddell Medal to Professor C. V. Boys.

THE SUREAL SELF-ACTING DAVIT.

(*For Description, see Page* 383.)

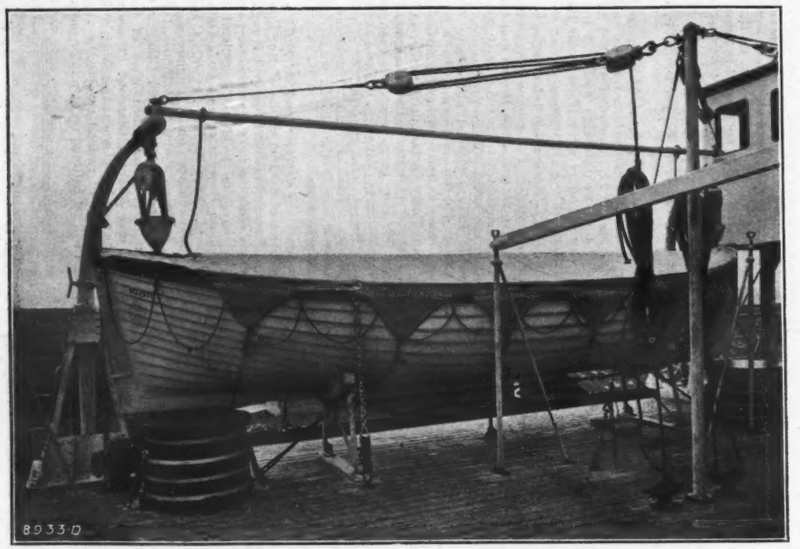


FIG. 5. BOAT HOUSED ON CHOCKS.

FIG. 6. BOAT PARTIALLY SWUNG OUT.

CORROSION-PROOF ELECTRIC WIRING SYSTEM.

THOSE of our readers who have experienced trouble from the corrosion of electric-light conduit and fittings in chemical works, bleach yards and other situations where they are exposed to the action of corrosive fumes, will be interested in a new wiring system recently placed upon the market by British Insulated and Helsby Cables, Limited, of Prescot, Lancashire. The system referred to consists of a range of cables and fittings completely enclosed in ebonite, this material being employed owing to the fact that its corrosion-resisting properties are probably higher than those of any other material commercially available for the purpose. On this system, single, twin and three-core cables of Association 600 megohm grade, and insulated with pure or vulcanised rubber, are supplied sheathed with a substantial tube of ebonite, all sizes being made up to an external diameter of $\frac{1}{2}$ in.

The joint boxes are of solid ebonite, and are made with two, three or four ways, which are fitted with screw glands to take the $\frac{1}{2}$-in. cable; rubber packing washers and ebonite screw-on covers render them gas and water-tight, while gland plugs can be supplied for closing up the ways which are not in use. The ceiling roses are of similar construction to the joint boxes, being provided with screwed glands and screw-on covers, but they are also fitted with an internal arrangement to prevent the weight of the pendant cable and lampholder from straining the joint. Two types of lamp-holder, for vacuum lamps, are made, one being intended for use with cab-tyre sheathed pendant cable, while the other is used with the $\frac{1}{2}$-in. ebonite-sheathed cable when a flexible suspension for the lamp is not required. In the latter type, the lamp-holder has an arrangement similar to the ceiling rose for taking the weight of the pendant cable, while for use with the cab-tyre sheathed pendant cable, a standard brass bayonet-socket lamp-holder, with the usual cord grip, is employed, enclosed in an ebonite shroud, the latter being made in two parts to facilitate the operation of wiring. Other fittings used include gas-tight and water-tight rotary snap switches and distribution boards of ebonite. In all cases the same type of cable glands are employed to prevent the access of corrosive fumes to any metal parts or to the core or insulation of the cables, the external surface being of ebonite throughout.

We understand that although the system has only recently been placed upon the market, it has been subjected to very severe practical tests over a period of three years with entirely satisfactory results.

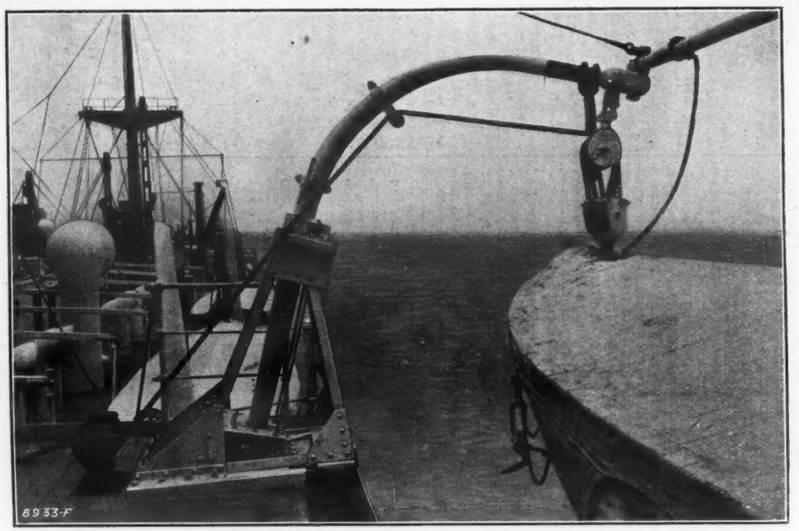


FIG. 7. BOAT IN OUTBOARD POSITION.

THE INSTITUTION OF PUBLIC LIGHTING ENGINEERS.—At a meeting of the council of the Institution of Public Lighting Engineers, held on January 17, it was decided that the annual meeting of the institution should take place in Leeds on September 14, 15 and 16 of this year. Simultaneously with this assembly an exhibition will be held showing the latest types of lamps and appliances in use for both the electric and gas lighting of streets. Application for space and further information by firms willing to exhibit should be made without delay to Mr. C. S. Shapley, Engineer and Manager, City of Leeds Gas Department, Market Hall, Leeds.

(To face page 372.)

THE REGULATION OF THE MURRAY RIVER; BLANCHETOWN LOCK AND WEIR.

(*For Description, see Page* 371.)

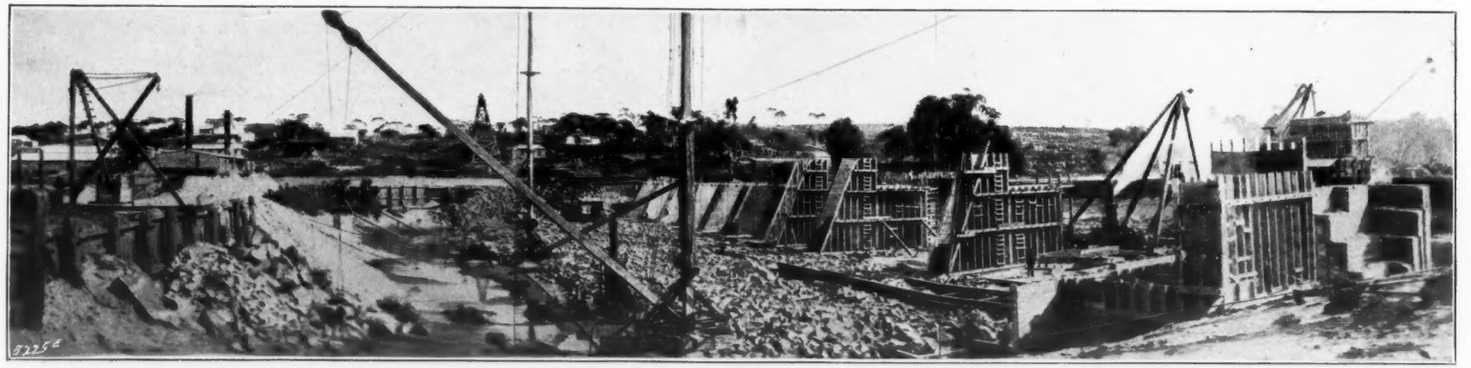


FIG. 12. THE LOCK UNDER CONSTRUCTION WITHIN COFFERDAM.

FIG. 13. LOCK AND WEIR, COMPLETED. VIEW OF DOWN STREAM SIDE.

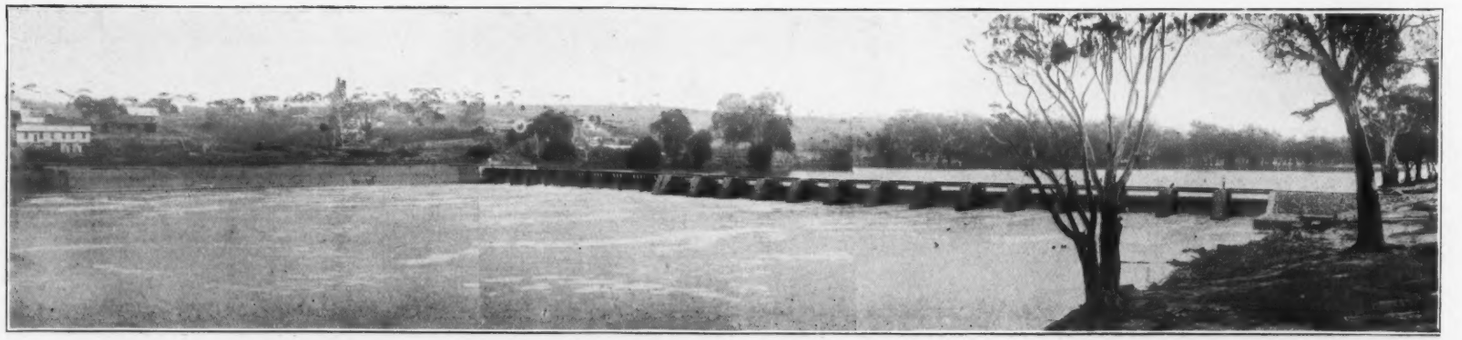


FIG. 14. LOCK AND WEIR, COMPLETED. VIEW FROM EAST BANK.

THE REGULATION OF THE MURRAY RIVER; BLANCHETOWN LOCK AND WEIR.

(*For Description, see Page* 371.)

FIG. 15. VIEW OF PILING FOR LOCK STRUCTURE INSIDE COFFERDAM.

FIG. 16. LOCK WALLS UNDER CONSTRUCTION WITHIN COFFERDAM.

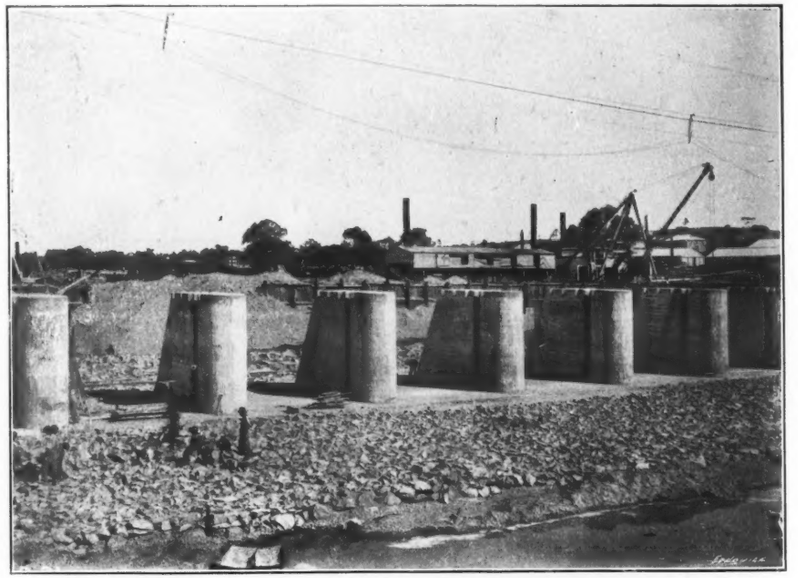


FIG. 17. PIERS OF SLUICE SECTION OF WEIR.

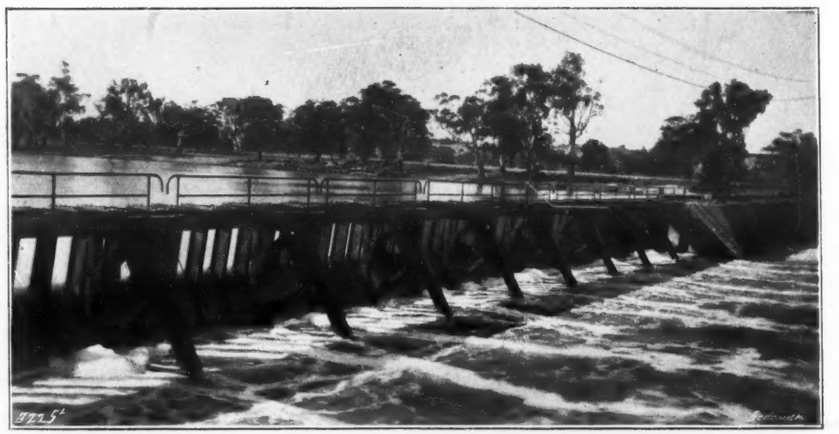


FIG. 18. NAVIGABLE PASS SECTION OF WEIR.

(*To face page* 373.)

HIGH PRESSURE COMPOUND LOCOMOTIVE FOR THE DELAWARE AND HUDSON COMPANY.

CONSTRUCTED BY THE AMERICAN LOCOMOTIVE COMPANY, SCHENECTADY, N.Y., U.S.A.

(*For Description, see Page* 381.)

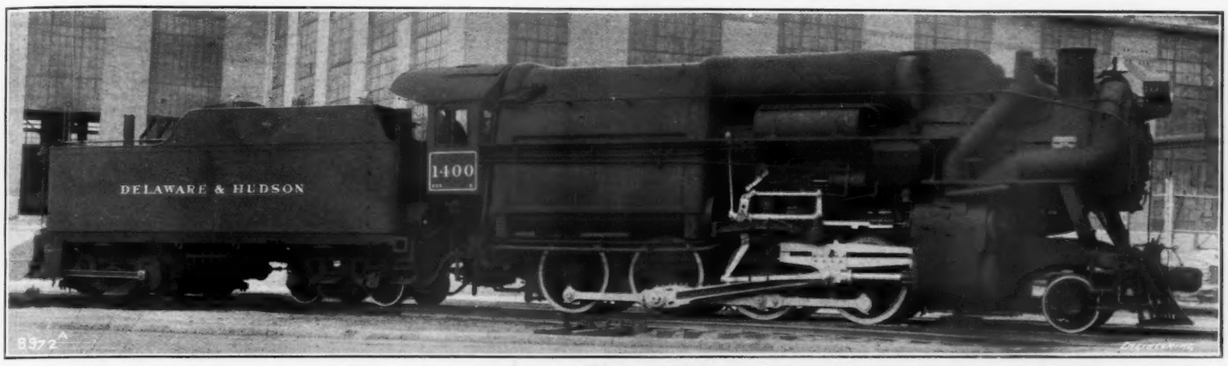


FIG. 1. GENERAL VIEW.

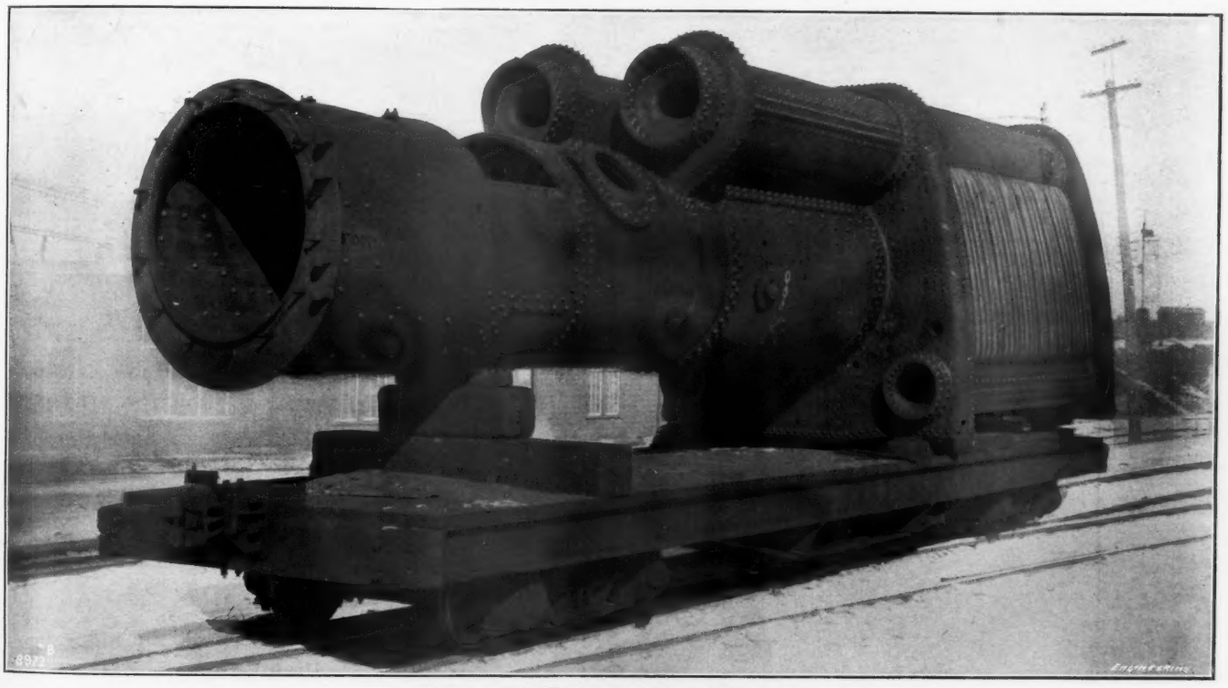


FIG. 2. THE WATERTUBE FIREBOX BOILER.

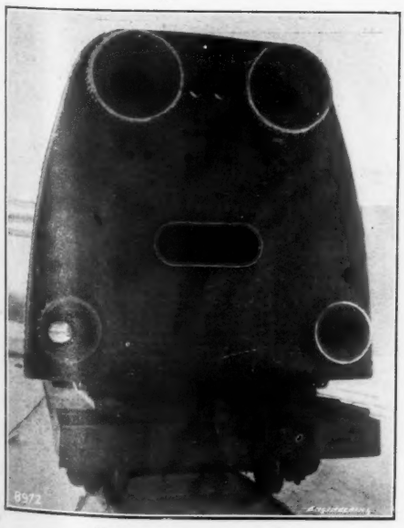


FIG. 3. THE BACK HEAD.

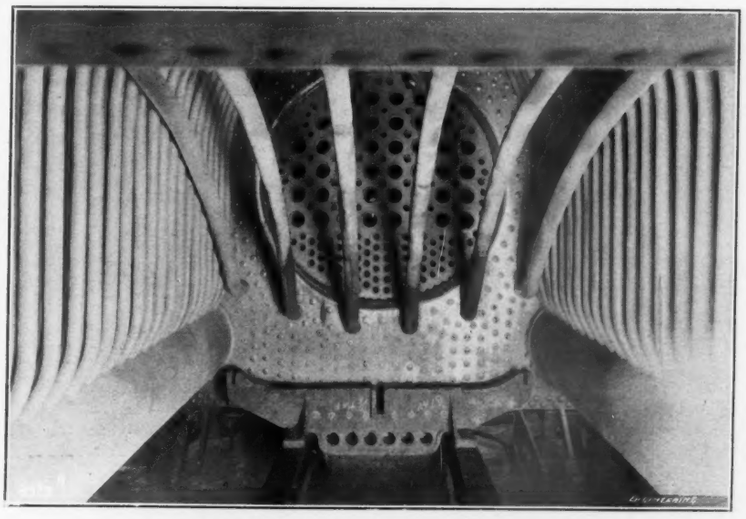


FIG. 4. INTERIOR OF WATERTUBE FIREBOX.

(*To face page* 380.)

HIGH PRESSURE COMPOUND LOCOMOTIVE FOR THE DELAWARE AND HUDSON COMPANY.

CONSTRUCTED BY THE AMERICAN LOCOMOTIVE COMPANY, SCHENECTADY, N.Y., U.S.A.

(*For Description, see Page* 381.)

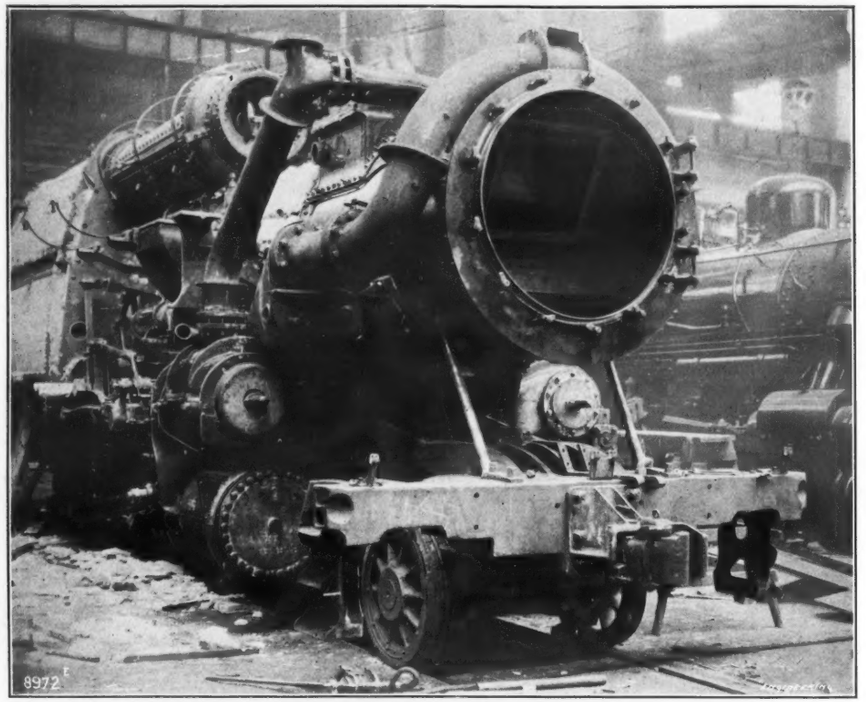


FIG. 5. THE LOCOMOTIVE IN COURSE OF ERECTION.

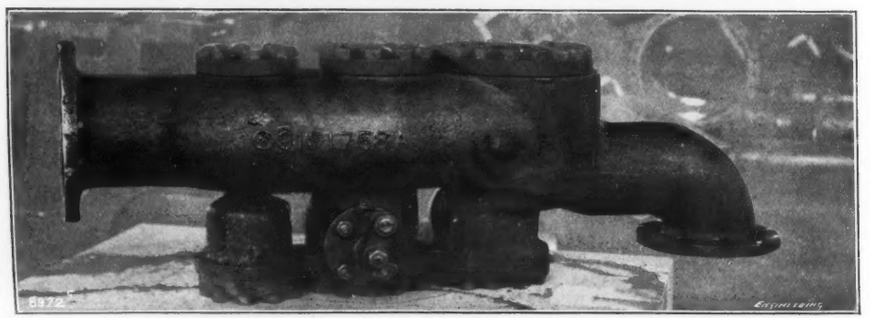


FIG. 7. THE DUPLEX THROTTLE VALVE CASTING.

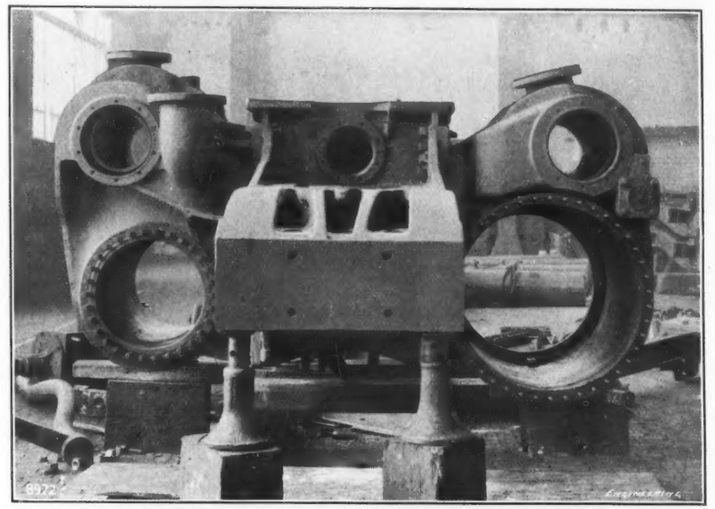


FIG. 6. THE CYLINDERS AND FRONT FRAME CASTING.

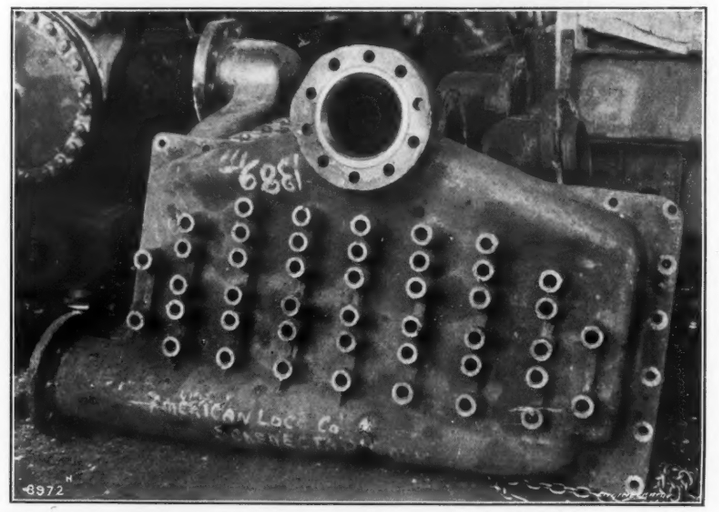


FIG. 8. THE SUPERHEATER HEADER.

(To face page 381.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3 5 0
For Canada—	
Thin paper copies	£2 18 6
Thick paper copies	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick paper copies	£3 7 6

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to "ENGINEERING," LTD. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia Melville and Mullen, Melbourne, Victoria.

BELGIUM, Brussels: E. F. Satchell, 86, Rue du Tabellion.

CANADA, Toronto, Ont.: Wm. Dawson and Sons, Limited, 87, Queen Street East.

EDINBURGH: John Menzies and Co, Limited, Rose-street.

FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque For Advertisements, Office de Publications Commerciale, 167, Rue Montmartre, Paris (2e).

GERMANY: Hermann H. Fromm, Lützowstrasse 84, Berlin. W. 35. A Twietmeyer, Leipzig.

GLASGOW: William Love, 231, Argyle-street. John Menzies and Co., Limited, West Nile-street.

INDIA, Calcutta: Thacker, Spink and Co., Bombay; Thacker and Co., Limited.

ITALY: U. Hoepli, Milan. Anonima Libraria Italiana, Torino, and any post office.

LIVERPOOL: Mrs. Taylor, Landing Stages.

MANCHESTER: John Heywood, 143, Deansgate.

NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.

NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.

ROTTERDAM: H. A. Kramer and Son, Limited.

SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and various branches and bookstalls throughout South Africa. Wm. Dawson and Sons (South Africa), Limited, 29, Long-street, Capetown.

TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 440, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church Street, New York.

CONTENTS.

	PAGE
Twenty Years' Work on the Pennsylvania Railroad Locomotive Testing Plant	371
The Regulation of the Murray River (*Illus.*)	371
British Trade with the West Indian Colonies	374
Literature.—Electrical Design of Overhead Power Transmission Lines. Simple Examples of Reinforced Concrete Design. Economics of Iron and Steel	375
Bridge Reconstruction Work of the Ministry of Transport—No. II (*Illus.*)	377
The Characteristics of Steam Boilers (*Illus.*)	379
High-Pressure Compound 2-8-0-Type Locomotive (*Illus.*)	381
The Hardening of Carbon Tool Steel	382
The Sureal Self-Acting Davit (*Illus.*)	383
A Third-Class Passenger Liner	383
Heavy Duty Worm Drive Milling Machines (*Illus.*)	383
Letter to the Editor.—Gunnery at the Battle of Jutland	385
Gas Masks for Petroleum Vapours	386
Books Received	386
Notes from South Yorkshire	386
Notes from Cleveland and the Northern Counties	386
Notes from the North	387
Notes from the South-West	387
Notices of Meetings	387
Corrosion-Proof Electric Wiring System	388
An Historic Parallel	389
Battleships versus Aircraft	390
The Marine and Small Craft Exhibition	391
The Institution of Mechanical Engineers	391
The Late Mr. Robert White (*With Portrait*)	393
The Coal Survey	394
Notes	394
The Late Mr. Charles Liddell Simpson	394
The Du-Ex Expansion Nipple (*Illus.*)	395
Notes on New Books	395
Labour Notes	396
Intermediate Chute and Maceration Scraper for Sugar Mills (*Illus.*)	397
Marine Oil Engine Trials (*Illus.*)	397
Catalogues	402
Cutting Tools Research Committee (*Illus.*)	403
ENGINEERING Patent Record (*Illus.*)	404

Four One-Page Plates.—THE REGULATION OF THE MURRAY RIVER, BLANCHETOWN LOCK AND WEIR; HIGH-PRESSURE COMPOUND LOCOMOTIVE FOR THE DELAWARE AND HUDSON COMPANY.

ENGINEERING.

FRIDAY, MARCH 27, 1925.

AN HISTORIC PARALLEL.

THE difficulty of instituting a comparison between the position of British engineers after the Napoleonic wars and that in which they now find themselves formed the subject of an address by Mr. John W. Hall, before the Midland branch of the Institution of Mechanical Engineers last week. The value of such discussion lies not so much in the information that is collected as in the conclusions that are suggested, and turns largely on the discretion with which the facts are chosen and the context in which they are arranged. The great provincial centres of industry have always had philosophical moods, and the men who have built up their industries have for hundreds of years delighted to exchange views with each other on subjects of much broader scope than the technique of their daily practice. In such discussions Birmingham has held and holds an eminent place, and Mr. Hall's address is a worthy successor to many others, in which men have been invited to withdraw their minds for the moment from individual details, and to consider the sum total of them in the light of past history and present experiences. Mr. Hall arrives at the familiar conclusion that as a whole the community must produce more or consume less; but in his comparison of the experience of British engineers in connection with the two last great European wars he reinforces this conclusion by considerations that sometimes escape notice.

It is, for example, not always properly recognised that the wars of Napoleon occurred early in the golden age of British engineering, which had been drastically alloyed long before the war of 1914. Mechanical engineering was then a new industry, and, by reason of its insular position and of the collocation of coal and iron not far from the sea, this country was practically the sole supplier of its products. The wars lasted over 20 years, and during that time the country spent on them something over three times its estimated annual income, besides subsidising its allies to the extent of about 10 per cent. of a year's income, and sending some 5 per cent. of its population into the services; but during that period its imports increased by one-half, and its exports much more than doubled. Even its shipping increased by 20 per cent., and was still quite insufficient for the trade that was offered. The ruin that the war brought on other nations had ultimately its inevitable result on our own trade, but in the times of terrible privation that followed the close of the war and extended into the "hungry forties," the construction of railways at home and abroad was by far the most notable set-off against collapsing employment. For engineers, indeed, with their locomotives and steamships, which brought corn to Liverpool from the virgin prairies of America for less than it had formerly cost to carry it from Lincolnshire, Mr. Hall claims a large share of the credit that usually goes to the politicians who repealed the Corn Laws in 1846. Even in those days monopoly was not enough to ensure business; but what engineering trade there was came to this country, and at that time the only limit to the trade of British engineers was the purchasing power of their customers.

The present situation is very different. The country may as before have spent something over three years' income on the war, but its subsidies to its allies have been not far short of an additional full year's income, and not 5 per cent. but 15 per cent. of its population were on military service, besides about half that number engaged with the help of a woman to every four men on producing munitions; in all, half the working population were employed exclusively on the service of the State, and paid at inflated rates that reflected the shortage of labour. These inflated wages, with the correspondingly enhanced bills for materials, had to be paid out of national capital or by money borrowed from abroad. Trade and manufactures, other than the production of munitions, declined. Apart from the cost of fresh plant manufacturers required largely increased capital to carry on even a smaller business than before. British tonnage, which in 1879 had been just on two-thirds of the total carrying power of the world, fell to little over one-third. These were burdens shared by all the industries of the country, but, as compared with their situation in 1815, the engineering trades are at still greater disadvantages. Whether in coal, pig-iron or steel we not only have lost our practical monopoly but are actually much smaller producers than other countries. Our prices are no longer limited by the mere purchasing power of our customers, but by the selling prices of powerful competing countries, who in addition to their superior reserves of fuel, have still greater reserves of oil and of water power than we can command. The figures of the order recently lost to Germany for five 10,000-ton motor vessels illustrate the extent of leeway we have to make up if we are to compete with that country. The lowest British tender was some 6*l.* per ton above the German price; but Mr. Hall quotes British figures for 1908 for 7,500-ton steamers at less than 5*l.* a ton.

These are not discrepancies that can be remedied by tinkering with relatively trifling details. Everyone is anxious that living wages, and more than living wages, shall be paid. Even before the economic value of contented workmen was recognised as clearly as it is now, manufacturers knew well enough that they made more money when wages were high than when they were low, and the type of employer that is likely to succeed and survive to-day sees in good wages an assurance of stability to his business that he dare not omit if it is possible to pay them. But, as Mr. Hall points out, works that are closed down or broken up cannot pay a living wage, or any wages at all; and at the present time there is no class of worker in the engineering trades to whose interests it is

1925. FIG. 8. THE SUPERHEATER HEADER. FIG. 7. THE DUPLEX THROTTLE VALVE CASTING. 31.)

not of more vital consequence to find means of cheapening the cost of production, regaining markets that are being lost or threatened, and stimulating the consumption that high prices have depressed, than to obtain any adjustment whatever of wages, however flattering it may seem on paper. The gap between costs as they are and costs as they must be if trade is to be put on its feet again is many times the aggregate amount of profit earned by employers.

Mr. Hall quotes a number of examples, including the figures given some little time ago by Sir Hugh Bell for the iron and steel trades, which show that in the engineering trades the men get the entire amount divisible between their employers and themselves with the exception of one-eleventh to one-sixteenth. If that small fraction, which includes the return on capital, were added to the men's wages, it would make no very appreciable addition, nor if it were taken off the customer's price would it make a sensible reduction. Far larger reductions of cost will have to be made if the situation is to be saved. The expense of employing more capital, and not less, will have to be faced if works are to be run to the best advantage, and, according to the high authority of Sir Charles Parsons, the income of works that wish to maintain their business must be able to spare from 1 to 3 per cent. of their turnover for experiment. In the instructive volume in which Mr. Ford has described how he made his trifling shop into the largest group of manufacturing works in the world, producing the cheapest products and paying the highest wages, he has outlined the methods he used. Among his principles two stand out as applicable to any class and any size of works. No man is employed on a job he cannot do well, or refused employment on one that he can. No man is allowed to do less than his best, or to work longer than allows him his due amount of leisure. The Ford establishments enjoy their remarkable advantages because they have earned them. The present most immediate business of engineers, their federations and their unions, is to help as many works as possible to earn the right to a similar standard of living. This cannot be attained before they have improved their efficiency to the needful extent, or even while they are doing so. The improved earnings will not have been earned and cannot be safely paid till after the improved production has been realised; but they will then have a permanence that no process of class haggling or bargaining can hope to yield.

BATTLESHIPS VERSUS AIRCRAFT.

IN September of last year President Coolidge requested Mr. Wilbur, the Secretary of the Navy, to consider the most recent developments in aircraft and their effect on naval policy, with a view to recommending the most efficient types of vessels for future service with the Fleet. It was stated at the time that the President had been very much impressed with the success of the American Army aviators in their world flight, and this prompted the request to Mr. Wilbur. It is probable, however, that Mr. Coolidge desired to obtain an authoritative opinion on the controversy which has been carried on very actively in the United States press for some time as to the relative values of the battleship, the aeroplane and the submarine for naval purposes, and particularly of the two former. The same question has been discussed at length in the Press of this and other countries, and will continually recur with any new and striking developments in either of the two newer weapons.

The Secretary of the Navy lost no time in appointing a committee to advise in the task the President had set him, and selected a special board consisting of seven admirals and the Chief of the Marine Corps. The Board was given power to call as witnesses anyone whom it was thought would give any useful information and opinion on the subject under consideration, and amongst those examined were the heads of the Navy and Army Air Services, their chief assistants, the leading aeronautical authorities, aircraft designers, and other representatives of the aircraft industry. The Board entered upon its work with commendable promptness and energy, holding daily sessions between September 30 and December 4. The matter was regarded as urgent, the President desiring competent guidance in his decisions on the naval appropriations for the coming financial year.

The Board took some time in preparing its report, which was sent to President Coolidge on January 17, its main recommendations being as follows:—(1) The six coal-burning battleships of the New York class to be modified to burn oil fuel, without delay; (2) the seven battleships of the New Mexico class to be modernised, as allowed by the Washington Treaty, as soon as possible; (3) the building of eight 10,000-ton cruisers to be taken in hand without delay; (4) three Fleet submarines, already authorised, to be laid down in 1927; (5) the authorisation of an airplane-building programme to ensure an adequate supply of the latest types of machine to the Fleet, at an expenditure during the first year of 20,000,000 dols.; (6) the completion of the Saratoga and Lexington as aircraft-carriers to be hastened; and (7) an aircraft-carrier of 23,000 tons to be laid down without unnecessary delay. The total cost of this programme was estimated by the Board at 80,000,000 dols. a year for three years.

If one is to judge from the indications as to urgency against each of these seven items, it might be concluded that, in the opinion of the Board, battleships and light cruisers were of more importance for fleet needs than aircraft or fleet submarines, and of the two last-mentioned types aircraft ranked before submarines. The United States has at the present time a larger number of submarines in commission and reserve than any other nation, and it is possible this may have influenced the Board in their recommendation so far as this type of war vessel is concerned.

The President was not fully satisfied with the report, and, according to some accounts, was disappointed with the Board's opinion as to the effectiveness of aircraft. It is more probable that the estimated cost of this programme was too great to warrant its serious consideration. The report was returned to the Board for further investigation, for a definite opinion as to the degree of urgency of each of the main items, and also a supplementary report as to the effect of an approved annual expenditure less than the 80,000,000 dols. mentioned by the Board upon the various items included in the report.

On January 31 the Board replied to the President and, with reference to the degree of urgency of the seven items, placed them in the following order: (1), (6), (2), (3), (5), (4), and (7). To effect a reduction in their estimated annual expenditure, the relative priority of items was slightly modified from that just given and one item deferred.

The President, basing his decision on these reports, recommended to Congress estimates for appropriations which include: (1) modification of three coal-burning battleships to oil fuel; (2) completion of the two aircraft-carriers Lexington and Saratoga; (3) 3,000,000 dols. for aircraft for the two carriers; and (4) the laying down of two 10,000-ton cruisers. The President also proposes to lay down some light-draught gunboats for patrolling the Yangtze River, vessels which have no effect upon the strength of the main fleet. The decision of the President appears to be a very wise one, for it adopts, but on a more limited scale, the special Board's revised recommendations, with the exception of the modernisation of the seven battleships of the New Mexico class as allowed by the Washington Treaty—an item which, if proceeded with, might have led to some objection being raised by this country, as there would appear to be at least two interpretations which might be placed on the relevant provisions of the treaty.

In its more detailed report, the Board deals with some of the arguments which have been brought against the retention of the battleship as the principal instrument of sea power, in view of the progress in development of the aeroplane and submarine. The members of the Board give it as their considered opinion, that the latest battleships of the U.S. Fleet can withstand any probable attack from aircraft or submarines.

To support this opinion, the experience in sinking the battleship Washington is described in the report. This vessel was complete so far as the hull structure was concerned, although not so in other respects. Five bombs were exploded near her, three of these containing 1,000 lb. of explosive and the other two each equal to the largest weight of explosive now carried by torpedoes. The three 1,000-lb. charges were detonated at the most effective depths, and at a distance from the ship's side well within the zone which had been claimed as an area in which such explosions would certainly destroy a ship. The charges corresponding to the torpedoes were detonated in contact with the hull and 13 ft. below water. After each of the explosions the hull was examined and the damage to the inner bottom was such that it could have been remedied by the ship's staff. A ship in commission, the report observes, would have had no trouble in reaching port under her own steam after the five explosions. The Washington remained afloat and rode out a gale for three days, being finally sunk by gunfire in 2¾ hours, 14 hits from 14-in. shells being required.

The protective decks of the ship were tested by dropping a 14-in. armour piercing shell weighing 1,450 lb., point downwards from a height of 4,000 ft. Although the decks were not penetrated, the damage sustained was sufficient to indicate that penetration would have been effected if the aeroplane had been at a height such as would be attained in war time. The Board considers the deck plating and supports should be strengthened. It is also stated that to secure one hit by the shell, two aeroplanes were required of which one made eight attempts and missed, whilst the other secured a hit at the fourth attempt. Reference is also made to the British experiments last summer with the battleship Agamemnon, which was bombed when under way. One hundred and fifteen bombs were dropped from heights varying between 5,000 and 12,000 ft., and not a single hit was scored. The two examples are quoted as illustrations of the great difficulty in securing hits on ships from aeroplanes in conditions immensely more favourable to aircraft than would be the case in actual warfare.

The report of the Board states that experience during the Great War emphasised the fact that at positions possessing efficient aircraft defence, hostile aviators were reluctant to attack at less than 12,000 ft. Although aeroplanes have greatly improved in the interval, so also have anti-aircraft guns, the new 5-inch U.S. weapon for this purpose being capable of sending a 50-lb. projectile to a height of 24,500 ft., at the rate of 14 rounds a minute.

Anti-aircraft practice in the U.S. Navy includes gun fire at a light fabric target towed by an aeroplane, and subjected to all the motions of the latter. The target in the form of a frustrum of a cone, is 14 ft. long, 54 in. in diameter at its leading, and 48 in. at its trailing end. The height at which it is towed is 4,500 ft., and analyses of the results shows that in not less than 75 per cent. of these practices the target is first struck by fragments of the shell, and finally is shot completely away. Although, the report observes, hits of aeroplanes will be more difficult at greater heights of the target, yet, on the other hand, hits on ships by the aeroplanes will be still more difficult. The Board records its opinion, that anti-aircraft guns mounted on ships are a better protection than aeroplanes against the attack of enemy aircraft.

The report further observes, that although the influence of the aeroplane on naval warfare will increase in the future, the contention of its advocates that it will secure paramount importance will not be realised. The battleship of the future will be so designed in the distribution of its armour on decks and sides, and in the watertight subdivision, that she will not be subject to fatal damage from the air. "It cannot be said, therefore, that air attack has rendered the battleship obsolete."

According to the Board, the most important elements of sea power are a powerful and efficient Navy, properly equipped and defended bases, and an adequate mercantile marine. The purpose of sea power is to support national policies and guard national interests in all parts of the world. This cannot be secured by air power alone, as aircraft can only operate from territory controlled by the

naval or military forces of their own country. The Board is emphatically against the creation of a united air service, and strongly advises the President not to agree to a separation of the Naval Air Service from the Navy.

The report of this special Board will be read with the greatest attention by those who are directly concerned with the same questions in this country, and by a far greater number who have been interested in the discussions on the matter in the British Press. Many will recognise that the opinions and recommendations of the Board coincide in all important respects with those reached five years ago by the responsible British authorities, and which in the interval have been strictly adhered to. The publication of the report will be followed by more acrimonious discussions in the American Press, for it is evident those journals which are particularly concerned with aeronautics are extremely disappointed with the opinions expressed by the Board on aircraft generally. One journal has already informed its readers that the members of the Board are incapable of either understanding or being entrusted with the air defences beyond the coast, and calls on Congress to order a complete inquiry into the whole question of naval defence. General Mitchell, who gave evidence before the Board, has been recently displaced from his position as head of the Army Air Service for his too frank comments on the Board's decisions.

THE MARINE AND SMALL CRAFT EXHIBITION.

THE third annual Marine and Small Craft Exhibition and Congress opened at the Royal Agricultural Hall on Wednesday, the 18th inst., and closes on Saturday, April 4. For the first time, the Exhibition is being held in conjunction with a Holidays, Sports, and Pastimes Exhibition, and as a result the exhibits are of a very varied nature. The small craft shown include both sailing and motor boats, but from the point of view of those interested only in the former, the Exhibition is likely to prove somewhat disappointing, as this type of craft is very sparsely represented. There is a moderate display of various types of motor boats, and, as in addition a number of firms specialising in the manufacture of motor-boat engines are also exhibiting, this particular side of the industry is pretty well represented. On the whole, the smaller types of motor-boat engines follow automobile practice fairly closely, and the makers have been able to take advantage of the experience of the automobile designer to produce engines which offer little ground for criticism either as regards design or finish.

In several cases of designs exhibited, it is noticeable that the controls are of the most flimsy and unmechanical description, and it is difficult to avoid the conclusion that they have been added after the engine left the makers' hands. One or two of the throttle controls exhibited, consisting of small diameter push rods of fantastic shape, would not be tolerated on a motor vehicle. They would undoubtedly collapse if any part of the mechanism were to jamb for any reason, and in the case of motor-boat service, this might conceivably occur at a very awkward moment. The air-cooled engine is unsuitable for boat work, and, as quite small powers are satisfactory in a number of cases, water-cooled engines of very small dimensions have reached a high degree of development for this particular field. A number of very neat engines of this type are to be seen at the Exhibition. Pump circulation is, of course, used for the circulating water, but, even with this provision, the extremely small-bore circulating pipes sometimes fitted hardly seem desirable, as they might be completely choked by a very small obstruction.

The majority of the engines shown run on petrol, but there are several examples of paraffin engines, in some of which the provision for vapourising the fuel appear to be inadequate. One or two firms exhibit engines designed to run on heavy fuels, and the motor boat offers a very promising field for this type. Up till the present, these engines have only been considered suitable for comparatively large powers, but one exhibited is only of 8/10 brake horse-power. This engine, which is manufactured by Messrs. Petters, Limited, of Yeovil, is shown fitted to a motor cruiser on the stand of the Walton-on-Thames Launch Company, and we hope to describe this vessel in detail in a future issue. Another example of a heavy oil engine is exhibited by Messrs. Bordewich (Engineering), Limited, of Hull, who show a 40-h.p. twin-cylinder "Ellwe" crude oil engine, with cartridge cold-starting equipment. The remainder of the exhibits generally follow conventional lines, the products of both boat and engine builders being notable in general for neat design and high-class finish.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the Institution of Mechanical Engineers was held on Friday last, the 20th instant, at Storey's Gate, Westminster, the chair being occupied by Mr. W. H. Patchell, past-president.

BENEVOLENT FUND.

Prior to the general meeting, the annual meeting of the Benevolent Fund of the Institution was held. The report of the Committee of Management and the accounts, which had been circulated, were taken as read and adopted, the Chairman pointing out that for the third year in succession the outgoings were greater than the receipts, there being an expenditure of 1,380*l.* 18*s.*, as against an income of 1,212*l.* 8*s.* 4*d.* He hoped something might be done to stimulate interest in the fund. Mr. J. K. Aykroyd, Sir Philip Dawson and Mr. A. J. Hill retired from the Committee of Management. Mr. Aykroyd, who was eligible for re-election, was again elected, and Sir Philip Dawson and Mr. A. J. Hill, who were not eligible, were replaced by Sir Ernest Petter and Major du Plat Taylor. The hon. treasurer, Mr. Norwood, the hon. secretary, Brig.-General Mowat, and the hon. auditors, Messrs. C. J. Haines and T. C. Pulman, were re-elected.

MARINE OIL ENGINE TRIALS.

The formal business having been transacted, Sir George Goodwin briefly summarised the contents of the Second Report of the Marine Oil Engine Trials Committee of the Institution, entitled "Trials of the T.S.M.V. Dolius." We reprint an abstract of the first part of this report, relating to shore trials, on page 397 of the present issue and will continue it in a later issue.

Mr. James Brown, who opened the discussion, said that the Dolius followed generally the usual practice of Messrs. Alfred Holt and Co., and the deck machinery was operated entirely by electric motors. The heating and cooking services were also carried out electrically, and during the trials at sea about half the electric load on the generator was absorbed for these purposes. All the steam used in the engines during the trials was generated by waste heat, except in the case of the special high-power trial. Reference had been made in the report to the difficulty of getting accurate exhaust temperatures close to the cylinders, which was due to the scavenge air blast mixing with the exhaust gases at that particular point.

In connection with the high mechanical efficiency it was to be borne in mind that the value of 91 per cent. was obtained because neither the blower nor the air compressors were driven from the main engines. The small loss, therefore, was entirely due to the friction of the engine itself. It would be seen that the torsion meter readings were obtained at the same time, but the results derived from them did not agree with the others.

When getting out the design he had been informed that there was a difficulty in getting revolutions up in oil-engined ships, and the design of the propeller was accordingly kept on the safe side. This was found to be erroneous, and he had concluded that in the engines in which such difficulties were experienced a value for the mechanical efficiency must have been assumed in the design which was too high. He concluded by expressing appreciation of the way in which the trials were conducted, and of his pleasure in being associated in such valuable work.

Lieut. G. W. B. Hext, R.N., of the Department of the Engineer-in-Chief of the Navy, spoke next. He said that he had accompanied the Dolius on her maiden voyage to Algiers and her return to Rotterdam last year, and gave a detailed account of the experience. The ship was loaded to within 500 tons of her full capacity and carried coal to Algiers. On arrival, a pilot who took the vessel straight into the berth for unloading coal, volunteered the information that the ship manœuvred remarkably well in response to the controls. Having discharged the coal, the ship was moved to another place where, after she had been loaded with iron ore, the manœuvring consisted of backing out, turning in the very limited space between the ends of the jetty and the breakwater of Algiers Harbour, and proceeding —still stern first—alongside the iron jetty. During those manœuvres upwards of 60 orders were received from the bridge in just under forty minutes. These were executed without the slightest hitch or hesitation, while it was to be noted that not more than one sprayer per boiler was alight the whole time. The results of the recorded consumption on the outward journey showed that, at the lower speed—122 r.p.m.—the consumption for all purposes was 8 tons a day, and at a speed of 128·5 r.p.m. just under 9 tons. At the lower speed the indicated horse-power developed was 2,250; at the higher speed, 2,450 indicated horse-power. It would be seen that the oil consumption per indicated horse-power-hour worked out at about 0·338 lb. per indicated horse-power-hour, just slightly more than the figures given in the paper. He would, however, remind the members that those figures were for fuel used for all purposes, and no attempt was made to allow for the electrical current which was used for such purposes as lighting and heating.

During the stay at Algiers opportunity was taken to open up No. 3 cylinder (port) and No. 2 cylinder (starboard) for examination. The condition of the cylinders was found to be very good indeed. The pistons were in good conditon and there was no carbon deposit on their crowns. The boilers were also opened for examination, and showed traces of oil in places. The return journey, from Algiers to Rotterdam, was not quite so fortunate as the outward journey, because the supercharging gear on the port engine broke down owing to a very slight accident. So far as could be traced, this was due to the dropping out of a split pin. It caused the key on the bevel gearing to be sheared; this put all the supercharge gear of the port engine out of order. It made a difference to the indicator cards, the compression pressure being less; but it appeared to have no effect on the consumption, because, on reaching Rotterdam, the consumption worked out at almost the same figure as the consumption on the outward journey, *i.e.*, 0·334 lb. per indicated horse-power-hour against 0·338 lb. for the outward journey.

Mr. Hamilton Gibson thought it would be generally agreed that the best marine engine, whether steam or oil, reciprocating or rotary, was that which for a given expenditure of fuel produced the maximum propeller-thrust. Intermediate records, indicator cards, torque measurements, &c., were useful and interesting from a research point of view, but for practical purposes it was the final result that counted. For himself, he would prefer to regard thrust horse-power as the real effective horse-power. He then described the thrust-meter equipment on the Dolius and other vessels, and its use. In a turbine or electrical drive the total load was practically constant, and was easily read on a dial indicating gauge. In a reciprocating job, whether steam or Diesel, there were considerable fluctuations of pressure, these fluctuations following the variations in torque. In cases where tests were made and the results were plotted the interesting fact emerged that the thrust curve lagged behind the torque curve by about 15 deg. This might have been a time interval or might have represented the total twist of the long propeller-shaft. At full power the propeller-shaft twisted about 1 deg. for every 10 ft. in length.

Mr. Gibson recorded his appreciation of the

open-minded attitude of the Admiralty—especially Sir George Goodwin—in trying out the thrust-meter in a geared-turbine cruiser in 1916. The application proved so successful that thrust-meters were shortly afterwards fitted to both thrust-blocks of H.M.S. Mackay, while similar apparatus was now being fitted in the case of foreign navies. He felt safe in predicting that, in marine propulsion at any rate, thrust horse-power would supplant shaft horse-power, just as shaft horse-power had ousted indicated horse-power.

Mr. Thomas Carlton referred to the fact that the mean pressure of the indicator card of the steam side was relatively low. It was interesting to note that with the low compression there was no missfire, and that a suitable temperature for the admission of the oil fuel had been easily obtained. Probably that was due to the circulation of hot water round the cylinder and to the piston-head; also to the absence of cooling effect of air injection. No starting air was used in the engine, and it was interesting and surprising to find in the report that the starting and manœuvring trials were so successful, considering that on the steam side the steam pressure driving the piston was only about half that of the compression pressure on the top of the piston.

Mr. J. W. Still referred to the scavenge-blower. As stated in the report, that machine was too large for the scavenging of one engine. That was but half the truth; it was twice as powerful as needed for both engines. When the blower was ordered, the size and power required for the eight cylinders could only be inferred from the tests of the single-cylinder arrangement in use at Greenock. It was not known what would be the effect of the changes created by coupling four cylinders to one exhaust pipe and of some other slight modifications being made. It was therefore deemed necessary to provide a blower of ample capacity. It had been decided to delete the electric motor in future sets and rely entirely on steam as the motive power for the scavenge-blower.

As a guide to the steam power obtained the heat drop through the turbine was given in Table XXII of the report, the figure for Trial 9 being 4,630 heat units per minute. Working at full power efficiency of the turbine, that represented a production of 89 h.p. at the turbine shaft, which meant that the steam produced by waste heat during the trial would have given a total of 222 brake horse-power if the blower unit had been of suitable size. The steam consumption per total steam brake horse-power developed would then have been 14 lb. per brake horse-power-hour—not a bad consumption. The combustion brake horse-power for that trial was given in the report as 1,282 h.p., but this had been arrived at without deducting the steam horse-power produced in the blower. The real combustion brake horse-power was therefore nearer 1,200 h.p., that was to say, the steam indicated horse-power of the cylinders was deducted, but the steam power produced in the blower was neglected. The total power capable of being added to the true combustion brake horse-power by waste-heat steam was therefore over 18 per cent., and was sufficient to overcome all the friction and negative work of the two-stroke combustion engine and its main auxiliaries. He thought it was not too much to say that in future large Still engines for marine service ample waste-heat steam would be developed to cover all those losses, with a small margin to meet contingencies.

Referring to the Committee's First Report, which dealt with the trials of a four-stroke engine, using blast-air injection, that engine gave an indicated thermal efficiency of approximately 38 per cent., or 1 per cent. higher than that obtained in the two-stroke Scott-Still set. The increase was amply accounted for by the blast air, which was absent in the Scott-Still engine. So far as the first stage in the production of power was concerned, the conditions were very similar. The regenerative plant only added 73·7 tons to the total weight of the machinery, or about 12½ per cent. For this added weight some 18 per cent. more horse-power was produced. It would be realised that boilers, condensers, air pumps and the like did not cost more, but less, per ton than Diesel engine machinery, and therefore the waste heat recovery plant actually reduced the cost of the entire installation per brake horse-power developed, at the same time reducing the fuel bill.

Mr. C. W. J. Taffs, the secretary to the Committee, observed that in the Report the different methods of arriving at the torque were given. He showed slides on which the results of the Sycamore and the Dolius were plotted to obtain the index to which the speed had to be raised to obtain proportionality to the torque. This demonstration manifested the great variations in the results.

Mr. E. B. Moullin, on the question of the calibration of the torsion meter, said that it was difficult to discover what caused the discrepancy in the results. In the case of the last Report the calibration method was described, but since then he had had an opportunity of making a statical test on a torsion meter of 400 h.p. He had sent a copy of his report to Mr. Taffs and had asked the latter to circulate it among the members. The predicted calibration and the actual static test calibration came within ½ per cent., showing that the method he had used was sound and could be relied on. The agreement between the measured horse-power and that predicted from model tanks was, he said, extremely close. He noticed that the torsion meter readings plotted against the torsion deduced from the indicated horse-power gave a good straight line, but the line did not go through zero. It seemed impossible that there could have been any zero error, because the zero was checked time and again by members of the Committee after the ship had been running at sea for many hours. When the ship stopped, members of the Committee again checked the zero, which came back dead right. He could hardly conceive that there could have been any error in the instrument while running, if, when the ship stopped, it invariably came back correct.

Mr. A. D. Bruce, of Messrs. Hawthorn, Leslie and Co., said he regarded the report as a fine record of the performance of the Still engine, and it was so complete as to make it of value to those interested in oil engine design. For comparative purposes, it would prove of greater interest when all the reports had been placed before the members. It was surprising to him that the Doxford two-cycle engine was able to put up a performance which seemed to approach that of the Still engine. The Doxford engine might, however, have approximated to its maximum possible economy much more nearly than was yet possible with the Still engine.

Mr. Mason said that when the torsion meter was indicating zero torque, a big current was flowing through the meter, and unless everything on the torsion meter was correct there would be an indication and the zero must be altered. The mere construction of the instrument, therefore, inspired greater confidence than would be placed in an instrument in which the zero was shown when everything was dead.

Mr. G. S. Baker said he had personally examined the torsion meter and seen the zeros checked, and had put it into the hands of one of his best mechanics, to see if any fault could be found, and apparently it passed examination. The zero was checked throughout the first day whenever opportunity arose, but there was a failure to check the zero at the end of the second day, not because it was not thought of, but because a man on board had an accident and the ship could not be stopped until it reached Greenock, when the gear had to be taken off at once because the Sycamore was waiting for it at Cardiff. Mr. Moullin had indicated the steps taken to get the zero, and as far as the speaker's information went, he believed Mr. Moullin's zero was correct. He had checked the meter at the Laboratory as far as zero and calibration were conerned. When it was brought back after the Sycamore trials it was sent to Dr. Stanton and re-calibrated, and the calibration and zero were found to be precisely as when the instrument left. So far as he knew, therefore, the thrust and torque measurements were correct.

With regard to thrust measurements, he had not been able to use the gauge fitted to the thrust-measuring gear; the fluctuations in it were far too large and rapid for rational readings. He was unaware that measurements were being made on this, or he would have endeavoured to check them. He was surprised to find, later, that these measurements had been put in. When using an ordinary gauge and turning the stop-cock down so as to cut out the fluctuations occurring, it would be found that true mean readings were not obtained. That was an actual experience, and it must be taken as a fact that the variations were very serious. He had used a special Bourdon gauge, made by the Budenburg Gauge Company, on the Dolius, and also the ordinary N.P.L. spring device described in the reports. The two thrust records were taken, on the same paper, with pens which had been lined up alongside one another; they agreed in their zero and absolute value, except at one revolution of the engine, when the Bourdon gauge showed violent fluctuation. Therefore, in that particular ship they had two records of thrust, agreeing in absolute magnitude and in variation, and he saw no reason to doubt that these were the true thrusts experienced at the port shaft. In conclusion, Mr. Baker referred to the method of taking the indicated horse-power of the engine. It would be seen that there was a very small diameter pipe with two right-angle bends in it; and, in his opinion, if there was any fault at all in the records it was that the indicator diagrams did not give a correct record of the pressures existing in the combustion chamber.

Admiral Sir George Goodwin then replied to the discussion which, he said, did not raise many questions that he could answer. He tendered on behalf of the Committee his thanks to Mr. James Brown and Mr. Still for the complimentary references they had made to the committee's work and for their contributions to the discussion. Mr. Gibson had remarked on the importance of thrust meters and the part they would play in the future when satisfactory readings could be obtained from them. He much appreciated the observations of Mr. Moullin and Mr. Baker, and he felt that in analysing the reason for the differences in the figures some headway had been made at the meeting. He trusted that the Committee would take the same view, and the hope would then exist of getting figures which could be placed with confidence before the Institution.

Mr. L. A. Legros stated that he had witnessed the trials, both in the shops and at sea, and he wished to say that though he was one of those who had checked the Moullin torsion meter, if anything was to be found out it would have to be found out by Mr. Baker, and that it was necessary to investigate the theory rather than the readings of observers. On the boat members of the Committee had looked over everything. He regarded the engine room of the Dolius as one of the best laid-out jobs he had ever seen.

The Chairman then brought the proceedings to a close by proposing the usual votes of thanks and announcing that an informal meeting would be held to-night, the subject for discussion being "The Cutting of Heavy Steel Sections." The next general meeting will take place on Friday, April 24, when the reports of the Hardness Tests Research Committee will be presented and discussed.

THE WILBUR-WRIGHT LECTURE.—The 13th Wilbur-Wright Memorial Lecture, which is delivered annually under the auspices of the Royal Aeronautical Society, is to be given this year by Rear-Admiral D. W. Taylor, of the American National Advisory Committee for Aeronautics. His subject will be "Some Aspects of the Comparison of Model and Full-Scale Tests," and the lecture will be delivered in the Library of the society at 7, Albemarle-street, London, W.1, on Thursday, April 30, at 8.30 p.m.

TENDERS.—The Department of Overseas Trade, of 35, Old Queen-street, London, S.W.1, have announced that the Municipal Authorities at Antwerp invite tenders for the construction of roadways and sewage works on the outskirts of the city. These tenders must reach the Burgomaster at Antwerp on the evening of April 6, 1925.—The Building Administration of the Riga town Council invite tenders until noon, April 20, 1925, for the construction of one quay section and six other sections required to complete a pontoon bridge across the Dvina river.

THE LATE MR. ROBERT WHITE.

IT is with the deepest regret that we have to announce the severance of a link with the earliest pioneers in railway work in this year of the celebration of the centenary of the introduction of steam locomotive traction. Mr. Robert White, who died at his residence, 66, Belsize Park-gardens, Hampstead, on Friday, March 20, after a strenuous life devoted to the improvement of railway facilities, principally in India, was at one time in partnership with the late Sir George Barclay Bruce, a protégé of Robert Stephenson.

Mr. Robert White was born in Glasgow on December 2, 1842. He received his technical education at the Andersonian University, now the Royal Technical College, Glasgow, while his early experience was obtained in works and offices in that city. First he served for some years in the Clutha Works of Messrs. P. and W. MacLellan, the constructional engineers, and then became a pupil of, and later on assistant to, Messrs. Forman and McCall, civil engineers, Glasgow. While engaged with the last-mentioned firm, he was employed on the work in connection with the Wemyss Bay, Milngavie, Busby and Blane Valley Railways. It was in this activity that Mr. White laid the foundations of the experience which was destined to be of great significance in the opening up by railway transport of great areas of the Indian Empire. In 1864 he first came into association with Sir George Bruce by his appointment as resident engineer on the construction of the Peterborough, Wisbech and Sutton Railway, which was built to the designs of Sir George. When this work was completed, Mr. White found his services required in a similar capacity for the Whitehaven, Cleator and Egremont Railway, where he was engaged on the completion of the Marron Valley extension and those to Egremont and Sellafield amongst others.

It was in 1869 that Mr. Robert White decided to go to India on being appointed a first-class assistant engineer to the Great Southern India Railway, and he remained in the service of that company and its successor for twelve years. Within this period he rose to the position of deputy chief engineer, and finally acted as chief engineer of the line. A large part of the metre-gauge system of what is now the South Indian Railway was constructed under Mr. White's charge in this part of his career. Returning to England in 1881, he undertook Parliamentary and other surveys, and later visited Asia Minor to report upon the property of the Smyrna Quays, and did similar work for the railway of the Rio Tinto Company in Spain, in connection with which he designed a large steel bridge.

Renewing intimate associations with Sir George Barclay Bruce in 1888, a partnership was formed by them, and they engaged in an extensive general engineering practice, which covered works in connection with the Buenos Ayres Grand National Tramways, the Rio Tinto Railway and Pier, the Beira Railway and Pier, and Ceara Harbour. Sir George Bruce had been appointed consulting engineer to the South Indian Railway many years earlier, and Mr. White became associated with him in this work, and was thus able to continue the valuable services which he rendered to this company in earlier years in another capacity. The partners were also associated in similar work for the Great Indian Peninsula Railway Company, and, with Sir Douglas Fox, Mr. White acted as joint engineer of the Cardiff Railway and carried out extensive and important works in connection with its construction.

On the death of Sir George Bruce, in 1908, Mr. White continued the practice of the firm in his own name, and devoted himself particularly to his duties as consulting engineer to the Great Indian Peninsula and South Indian Railway Companies, which involved the design of many important works. He also acted in an advisory capacity to a number of railways in various Indian States. In 1919 Mr. White took into partnership his chief assistant, Mr. Cyril Hitchcock, and his son, Mr. Bruce Gordon White, and they practised under the style of Robert White and Partners. They were joined by another son, Mr. Colin Robert White, in 1923.

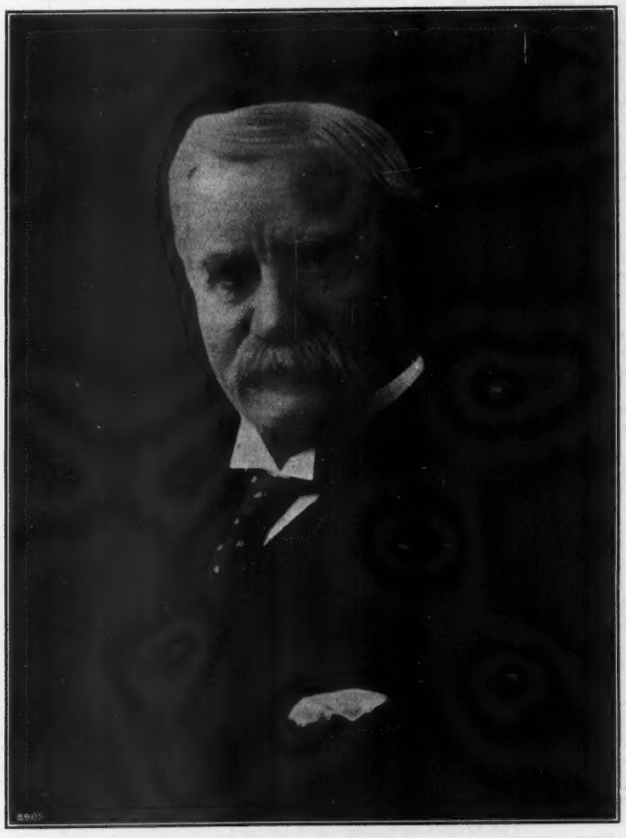


Photo by Vandyk.

THE LATE MR. ROBERT WHITE.

At the close of the European war, the question arose of removing the main works of the Great Indian Peninsula Railway from Parel to a place outside the Bombay area and a great amount of preliminary work was done in connection with this proposal. Financial difficulties, however, led to the decision to suspend any action of the kind for the present, but other schemes were mooted to effect economies in working and the improvement of the service. Amongst these, consideration was given to the savings that might be effected by the introduction of electrical operation of parts of the system. After a complete investigation had been conducted into the questions involved in the conversion, a very large programme of electrification was adopted. Just as has been the case in almost every part of the world, the first portions to be dealt with were the suburban lines of large cities. The first section has now been completed and put into successful operation. It comprises some eleven miles or so of the Bombay suburban system. The formal inauguration of this new electric train service took place as recently as February 2 of this year. A beginning now having been made, the continuous extension of electric traction to other parts of the Great Indian Peninsula Railway and to other lines may be anticipated, and much of the preliminary work for the lines with which Mr. Robert White was associated has already been done. Mr. White saw the growth of the Indian railway systems from very early days and, indeed, was responsible for a large part of their development. It is thus a remarkable thing that a pioneer of his standing should have witnessed the introduction of a new method of propulsion which, it is anticipated, will greatly increase the value of the railways to the Indian Empire, a purpose to which he devoted his life.

Mr. Robert White was elected a member of the Institution of Civil Engineers in 1870, and served for a number of years on the committee of management of its Benevolent Fund. He was also a member of the Institution of Mechanical Engineers and of the British Engineering Standards Association, serving on the Sectional Locomotive Committee from its formation. Other valuable work was done by him in connection with the Locomotive Conference formed at the request of the Secretary of State for India to prepare designs for standard types of locomotives for Indian railways. He was a member of the Sub-committee on Iron for Railway Rolling Stock from 1907, when it was set up, until he retired from active participation in the work of the Standards Association in 1920.

THE COAL SURVEY.

A FURTHER instalment has been published of the reports by the Fuel Research Board on the Physical and Chemical Survey of the National Coal Resources,* describing laboratory experiments carried out for the Department of Scientific and Industrial Research by the Lancashire and Cheshire Fuel Research Association. Like the Arley seam, described in the previous report, the deposit investigated is part of the Lancashire coalfield, but, whereas the Arley seam was chosen for its singular consistency throughout the wide area it covers, the Ravine seam is an example of a deposit that, although clearly recognisable over a large area, appears to be a confluence of a number of shallower deposits with intrusions of dirt and shale, and shows a wide variation in its chemical and physical constitution. Though the thickness of the seam from roof to floor varies from about 5 ft. to 10 ft., the good quality coal in a workable thickness of 6 ft. at the best part of the seam is not more than 4½ ft. to 5 ft., and in the extreme east of the area, in which it has been proved, there is generally only 1 ft. of good coal out of a thickness of 5 ft., which is economically unworkable.

The general run of the good coal is fairly strong and lustrous, though a little duller in appearanc than the Arley coal, and a little denser. It is a bituminous, caking coal, used for gas making, manufacturing and household purposes. It lies above a large part of the Arley deposit at heights varying from 150 ft. to 500 ft. Partly because of its variability and partly because of its marked tendency to spontaneous ignition in the goaf, it is not worked to the same extent as other seams. It is, however, an important deposit, and the present report shows separately the composition of a number of bands in complete sections taken at each of seven localities at various parts of the seam. These data, minute as they are, must be read with the qualification that even in a few yards the composition may be entirely altered through the intrusion of dirt and shale; but they serve to indicate both the sort of variations that may be found in various bands of the same vertical section, and the thicknesses in which relatively uniform coal may be expected as a general rule.

Both in respect of ash and of sulphur the proportion is often inconveniently high, but whereas it appears that as a rule the coal can be washed free from ash to a high degree of purity—though sometimes the dirt is mixed so intimately with the coal that for efficient separation it has to be ground to a greater fineness than can be handled by coal washers, the effect of washing on the sulphur contents is much less. A special examination was made of the ankerites—the inorganic partings found in lumps and along bands—in view of the fact that these bodies, which are substituted carbonates containing magnesium, iron and manganese, oxidise very rapidly when exposed to the air, and thus cause the coal to disintegrate. In this condition it is more readily oxidised by air in the goaf or in storage, and thus probably more apt to ignite spontaneously. The oxidation, indeed, is much more rapid than that of ankerites found in other seams; within a short time of the exposure of the seam to air the white layer turns to a deep brown. Bands of durain and both bands and lenticular deposits of fusain are found from time to time in the sections.

The Lomax Palæobotanical Laboratories, working under the Lancashire and Cheshire Coal Research Association, with assistance from the Fuel Research Board, have made a complete microscopical examination of the seam at what is regarded as its standard locality. In connection with this examination photomicrographs have been taken layer by layer from floor to roof of horizontal and vertical sections, exhibiting the plant structure and other characteristics of the deposit at every depth. Copies of the report on this examination are filed at the Laboratories and in the Survey Section of the Fuel Research Board, where the sections themselves are preserved. It will be remembered that these sections are thin transparent laminæ, the technique of the preparation of which has been mainly worked out by Mr. Lomax. It is perhaps too much to say that a practical interpretation can yet be placed on these beautiful and interesting specimens. Apart, however, from their intrinsic merits, they seem to be an excellent example of the application of pure research in the nascent stage, when it is too soon to say whether in fact it can be put to any practical use, and when the possibility of its leading to valuable results is sufficient to justify and, indeed, demand, that it should be continued.

A series of tests are being conducted on this coal at the Fuel Research Station in respect to its value in steam raising and its behaviour under carbonisation at high and low temperatures, the results of which will be published in due course. The variability of the seam suggests that much of it may possibly be best used as pulverised fuel, and further investigation is to be made on the melting point of the ash of the coal as raised, so as either to establish its suitability for use in particular systems of pulverised fuel combustion, or to determine what blending with other grades of coal will modify the melting point suitably.

* No. 4. The Lancashire Coalfield: The Ravine Seam. Part I. H.M. Stationery Office. 1s. 6d. net.

NOTES.

ECONOMIC CONDITIONS AND THE ELECTRICAL INDUSTRY.

IN the annual address of the chairman of council of the British Electrical and Allied Manufacturers Association, which Sir Benjamin Longbottom delivered at a luncheon of the members in the Connaught Rooms, London, on Thursday of last week, he referred to the conditions prevailing in the electrical industry in 1924 and the possibilities of the immediate future. The first effects of the Dawes scheme had, he said, been to cause a real improvement in the economic situation of Europe, but there were factors which demanded consideration if the electrical industry was to benefit by the altered financial and trading conditions. Unfortunately, those countries, which were generally supplied with electrical plant by Germany, Austria and Switzerland, were the first to recover economically. This was the most significant feature in the international situation, for it must have the effect of strengthening the German position in the control of Central European trade. The change of spirit in America towards penetration into European trade had led to a steady flow of gold from the United States. This had been responsible for the appreciation of the British exchange rates, but while the return of sterling to par might be a good thing in itself, it might also lead to the manipulation of the bank rate to keep sterling at par, although other conditions tended to lower its value in New York. A bank rate rise to 5 per cent. at present was a source of danger to trade at home and a further obstacle to competition abroad. The last five years had shown the danger of interfering with economic conditions or of trying to control trade through adherence to a rigid financial policy. This, though a question for the banks, was important to the manufacturers. The British Dominions and Colonies absorbed two-thirds of the total exports of electrical machinery in 1923. If the trade with British territories overseas had remained at the pre-war proportions 86 per cent. of our exports of electrical plant in 1923 would have been accounted for. The value of these markets was thus increasing at a greater rate than our exports to them, and the challenge of the United States was becoming serious. Canada had almost ceased to be a British market for electrical goods, while Australia absorbed a greater percentage of American manufactures every year. Although the future would show a revived Germany, with a smaller taxation than Britain, and the United States determined to use their gold accumulation for the financing of trade, Sir Benjamin Longbottom anticipated improvements in the demand for British goods through the steady movement upwards in the fundamental economic conditions which were the foundations of sound trade.

NON-FERROUS ALLOYS.

The field of application of the non-ferrous alloys widens but slowly, in spite of the fact that during recent years there has been considerable progress in the smelting and purification of non-ferrous metals and the casting and working of their alloys. There would, at present, appear to be little chance of the latter competing with steel where properties of strength and reliability are most important and it is only when some other property is of equal or greater value that non-ferrous alloys may be preferred. Such were the general conclusions arrived at by Dr. G. H. Gulliver in a short paper entitled "Progress in the Practical Application of Non-Ferrous Alloys," read before the London section of the Institute of Metals on the 19th instant. He stated that the history of metals largely consisted of the replacement of non-ferrous metals by iron. The latter had, however, never successfully replaced non-ferrous alloys for coinage, for type and for bearings, but it remained a serious competitor with aluminium even in circumstances where lightness was of importance. The fact that the sources of supply of many of non-ferrous metals were limited was well known, and it might become necessary to restrict the use of such materials to certain purposes. The application of coatings of non-ferrous metals to iron articles would then become of greater importance, and improved methods would result. A more judicious selection of alloys used for industrial purposes would also effect economy. For instance, a copper-zinc alloy could often be replaced with advantage by a copper-nickel alloy. Giving an example from his own experience, the lecturer stated that a locomotive boiler fitted with cupro-nickel tubes, the nickel content of which was 4 per cent., was still giving efficient service after a lapse of fifteen years, while the brass tubes of a locomotive boiler under similar conditions had given out after a few years' wear. The composition of the "hard brasses" was becoming increasingly complex, and the series offered a wide field for investigation. In conclusion, the lecturer stated that there was little likelihood of any non-ferrous alloys rivalling steel for ordinary constructional purposes, and it would, therefore appear desirable to develop the former for the purposes to which ferrous materials were unsuited

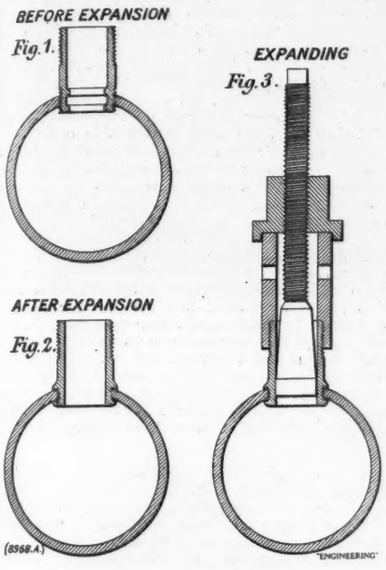
THE LATE MR. CHARLES LIDDELL SIMPSON.

MR. CHARLES LIDDELL SIMPSON, who, we regret to state, died on March 12, in his 63rd year, was educated at Wellington College and received his early training in engineering at a technical school in Hanover, and at the engine works of Messrs. James Simpson and Co. He afterwards worked for some eighteen months in the shops of the Wallsend Slipway and Engineering Company. In March, 1884, he became a managing director of the firm of Messrs. James Simpson and Co., Limited, in which capacity he remained until 1909. While holding this position, pumping machinery for many metropolitan and provincial water companies and for Indian, Australian and South African undertakings was constructed under his supervision. He was responsible for the designing and erection of the new works of the firm at Newark-on-Trent. In 1909, he became a director of Messrs. John Russell and Co., Limited, Alma Tube Works, Walsall, Staffs. He took charge of their London business and also became actively engaged in modernising and extending their brass works. In 1922 he was appointed consulting engineer to the Folkestone Waterworks Company. He was elected an associate member of the Institution of Civil Engineers on February 7, 1888, and a full member on January 8, 1924.

GREAT WESTERN PORTS, 1925.—Previously issued under the title "South Wales Ports," the handbook published yearly by the Great Western Railway Company is, on this occasion, entitled "Great Western Ports, 1925." The change in name has been made on account of the inclusion of, and extended reference to, other ports of the company in addition to those discussed in the earlier handbooks. The latest volume, a particularly handsome one, provides complete information regarding the capacities and equipment of wet and dry docks, the cold storage spaces available, and the rates, dues, and charges enforced at the ports of Cardiff, Briton Ferry, Neath, Swansea, Lanelly and Burry Port, Plymouth, Milford Haven, and Fishguard. Statistics of imports and exports registered at the latter are included for the years 1911 to 1924, while a series of articles on the coal, grain, oil, shipping and other trades are given, in addition to comprehensive particulars of the iron and steel industry. A number of excellent dock and railway maps and many illustrations further increase the utility of the work, copies of which may be obtained by business houses, free of charge and postage, from the Chief Docks Manager, Great Western Railway offices, Cardiff.

THE DU-EX EXPANSION NIPPLE.

A NEW and improved form of expansion nipple, which is especially suitable for making service connections to steel gas or water mains, and other thin pipes, although it may also be used for making branch connections to spun or thin cast-iron pipes and steam pipes, as well as for connecting pipes to tanks, &c., has recently been placed upon the market by Messrs. J. Stone and Co., Limited, of Deptford, S.E. 14, who describe it as the Du-Ex expansion nipple. The nipple, and the special tool used for applying it, are



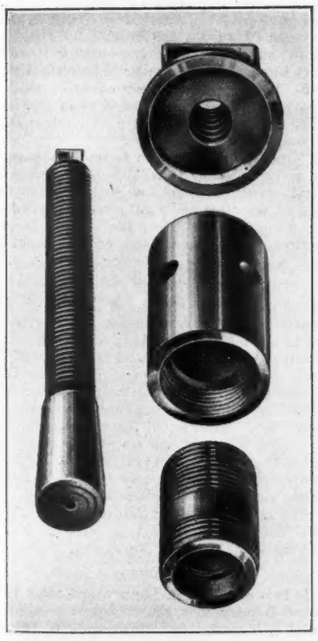


FIG. 4.

illustrated in the accompanying Figs. 1 to 4, of which Fig. 1 shows the nipple inserted in the pipe in the form in which it is supplied by the makers, while Fig. 2 shows the connection completed.

The nipple, which consists of a short length of drawn-steel tubing, is screwed externally at each end and machined internally so as to form two annular beads, one at the extreme end of the nipple and the other farther in, leaving a space between the two beads about equal to the thickness of the pipe to which the connection is to be made. After screwing the nipple into the pipe, these beads are expanded, as will be explained later, so as to form ridges on the outer surface of the nipple, one inside the pipe and the other outside, as shown in Fig. 2. The expansion serves both to force the threads of the nipple into intimate contact with those of the pipe, and to rivet the metal of the nipple over the edges of the joint so that the resulting connection, the makers claim, is both mechanically strong and tight against any fluid pressure that the pipe is capable of withstanding.

The expansion is effected by the tool shown in use in Fig. 3, the three parts of which it is composed being illustrated separately in Fig. 4, together with one of the nipples. In making a connection, the nipple is first screwed into a stout tubular sleeve, and a tapered mandrel, having a long screwed stem, is then passed through the nipple and sleeve. The parts are held together by screwing up a flanged nut on to the stem of the mandrel, the flange of the nut fitting over the end of the sleeve as shown in Fig. 3, and the smaller end of the tapered mandrel making contact with the lower of the two beads on the inner surface of the nipple. By means of a claw spanner, the nipple, with the expanding tool in position, is then screwed tightly into a hole previously drilled and tapped in the pipe, and the connection is completed by turning the flanged nut with a ratchet spanner, so as to draw the tapered mandrel up through the nipple. If the mandrel tends to slip during this operation it can be held by the claw spanner applied to the upper squared end. The largest diameter of the mandrel is equal to the full bore of the nipple, so that the effect of drawing the mandrel through the nipple is to displace the metal of the beads, as explained above, leaving a smooth clear passage for the flow of the fluid. The sleeve, nut and mandrel can then be removed, and a pipe connected to the nipple by a socket or union in the ordinary way.

The nipples and expanding tools are made for ½-in. to 2-in. connections, and they can be used without modification on steel pipes of any diameter. Nipples with the beads suitably spaced for spun and thin cast-iron pipes can be provided. The makers also supply the necessary apparatus for making connections to mains under pressure.

NOTES ON NEW BOOKS.

A SYSTEMATIC and exhaustive account of the mineral resources of the country is eminently desirable, but is difficult of attainment owing to the continual change effected by mine development and exhaustion. A comprehensive work on the "Iron Ores of Great Britain" was first published by the Government in the years 1856-1862. Additions have been made from time to time as new mines were brought into operation and old ones abandoned. An abnormal demand for iron ores during the war, following a period of active development, necessitated a thorough revision of the sources of information, with the result that in 1918 an authoritative account of the occurrences of iron ores in the N.W. of England was issued from the Geological Survey Office. This work has now been superseded by a second edition, or new volume, forming a section of the Special Reports on the Mineral Resources of Great Britain, under the title "*Iron-ores Hematites of West Cumberland, Lancashire and the Lake District*," by Barnard Smith, M.A., Sc.D. The work is published by H.M. Stationery Office at the price of 5*s*. net. The responsible author has been resident in Whitehaven for the past three years and has worked over the district with great care, being aided by many amateurs and experts who have given freely of their knowledge and experience. It is impossible to do justice to the amount of detail collected, but all who are interested in the iron fields of this restricted area will welcome the publication. The industry seems to be stationary at present. Taking Cumberland as a sample the output of hematites in recent years is about a million tons of a value slightly exceeding 2,000,000*l*. The reserves and future prospects of the industry are discussed with thoroughness and insight, the conclusion being reached by Dr. Smith, that there is no reason why the industry should not enjoy a period of continuous prosperity, for new mines follow as others are abandoned. No conjecture is made of the probable life of the hematite mines, nor does any estimate seem possible without a surer basis for further conclusions than has hitherto been available. The survey of the past, however, affords an interesting description of the geology of the iron fields, with the manner of occurrence of the ore bodies, in which is traced their probable origin and the order of formation. The importance of a knowledge of the character and occurrence of the younger rocks that overlie the carboniferous limestone is emphasised. On the commercial side the detailed account of the development of the mines and of the methods of mining is both interesting and valuable. The list of plans of abandoned mines will be of service as providing much useful information.

The subject of relativity has ceased to be a nine days' wonder and the popular press is no longer interested in the paradoxes occasioned by the view that time and space are to a certain extent convertible terms. Serious students of the subject are, however, more numerous than ever, and these will find a particularly able exposition of the doctrine in "*Relativity and Common Sense*," which has recently been published by the Cambridge University Press at 10*s*. 6*d*. net. The author is Professor F. M. Denton, of the Northampton Polytechnic Institute. At the outset the author is careful to point out that the whole scheme only represents "reality" in a strictly limited sense, and relativity cannot, of course, ever be accepted as an ultimate explanation of the universe. Logically developed, however, it has led to the prediction of many unexpected phenomena, which have since been disclosed by experiments. Mathematically the theory is exceedingly awkward to handle, and the practical physicist or engineer will for long to come, and perhaps indefinitely, find it more convenient to think in terms of forces acting on masses, which may at need be considered as variable, rather than in terms of the crumpling of a space-time continuation. Some are sufficiently sanguine to believe that mankind will ultimately develop the faculty of thinking in terms of four dimensional space, but we fancy that this expectation will be doomed to disappointment. As the author states, relativity recognises neither force nor motion, which we should ourselves interpret as an indication that it is merely a generalisation convenient for some purposes rather than an ultimate truth. The treatment of the subject in this volume is as simple as the matter admits of, and is not confined to the restricted theory. The author must be congratulated on having given so full an exposition of the doctrine without making an excessive demand on the mathematical attainments of his readers.

Although pyrometry has now become an exact science, many of the smaller metallurgical firms still rely on rough visual tests for gauging temperatures, which when applied to heat-treatment operations often produce unsatisfactory results. The correct annealing, quenching, and tempering temperature for any class of steel lie within such narrow limits that articles turned out under these haphazard conditions are usually not uniform in quality; some prove quite satisfactory in service, while others fail to attain the required standard of maximum usefulness, the latter being due, in the majority of cases to incorrect heat-treatment. A new book, which aims at dealing in a practical and straightforward way with the subject of heat-treatment is "*Heat-Treating, its Principles and Applications*," by C. H. Fulton, H. M. Henton, and J. H. Knapp, issued by the Penton Publishing Company, 2-3, Caxton House, London, S.W.1, price 14*s*. net. This deals with the thermal treatment of plain carbon and alloy steels, both from the practical and from the scientific points of view. The chapters devoted to the study of crystalline structures and their relation to physical properties are of a somewhat elementary nature and are obviously intended for practical men; controversial topics and matters of purely academic interest are wisely left out. Other chapters on current shop practice are included for the information of scientific men. A noteworthy feature is the endeavour on the part of the authors to give definite meaning to various shop terms and to reconcile works terminology with the generally accepted scientific definitions. The work is well illustrated and contains a number of useful tables, graphs and diagrams; the photomicrographs are specially well selected. In the chapter on annealing, for example, the influence of the temperature factor in normalising is well demonstrated by a series of photomicrographs; even an untrained eye is able to select the correct normalising temperature-range. The effect of temperature on grain size is a subject, the importance of which is fully emphasised. Furnaces of all types are described at length and furnace efficiency, a question which, in these days of high costs of fuel, should receive the closest attention, is considered in detail. It is evident that the authors are practical, and have devoted much of their time to research work. The logical and painstaking way in which they have dealt with what has always been an intricate subject is certain to appeal to a wide circle of metallurgical men.

MOTOR TAXATION AND REGISTRATION.—A useful booklet has been issued by the Automobile Association entitled "The Motorist's Guide to Motor Taxation and Registration," in which the various legal requirements connected with the purchase or sale of cars or motor cycles, the surrender of licences and many points relating to the registration book are simply explained. Tables are supplied which show conveniently for any period of the year the tax payable for annual or other licences. Copies of the publication may be obtained free from the Secretary of the Automobile Association, Fanum House, New Coventry-street, London, W.1.

LABOUR NOTES.

THE evidence given by Lord Weir before the Court of Inquiry into the steel houses question ought to go a long way towards re-assuring reasonable trade unionists that Messrs. G. and J. Weir's proposals are not only fair but generous to the workers. Lord Weir said that when his firm originally made their decisions they knew that they were not going to call for any craft skill from their operatives either of the building crafts or any other craft. Their function was to carry out the simple operations the firm had devised, and this meant that all their operatives could be recruited from the unemployed. To be entirely consistent, Messrs. Weir could have engaged unemployed labourers, but on reviewing the situation they decided to give a definite preference to the employment of idle craftsmen of the trades hardest hit by the present depression. Next they had to decide what rate of pay to give them. They might have created a rate somewhere between a labourer's rate and the craftsman's rate in these men's own trades—in other words, a sort of semi-skilled rate. Alternatively, they might have given each man the rate of his own trade. Against the first idea they felt that there might be a feeling of degradation on the part of a craftsman at being only a little over a labourer's rate. Against the second proposal there was the obvious objection that it would mean a variety of rates for the same work.

Accordingly, Lord Weir went on to tell the Court, after full consideration, they decided to adopt as a rate the engineering standard rate of the district. This rate was, if anything, over the average rate of the unemployed crafts in the district. To Messrs. Weir it appeared to be a fair and just rate of pay. They felt that an idle craftsman would consider he was fairly treated if given a simple job and paid as much as he would be paid if he worked at his own craft. Bluntly, there could be no question of either degradation or sweating. Here he would like to say that they did not consider at this stage that they could reasonably be asked to even consider paying any of the building trade rates to these men, and they adhered to this view. Apart from the considerations he had dealt with in regard to the lack of exercise of craft skill and to the application of mass production manufacturing methods, they could find nothing whatever to justify them in engaging idle engineers or shipyard workers to do simple work and then to give them a rate of pay 30 per cent. in excess of their own trade. Any such proposal would, in their view, have been unfair to everyone concerned. It would be unfair to the building trades, to the other trades, and to the nation in the form of the tenants and the community, who finally paid for the houses. These decisions on rates were made for all operatives whether engaged in the factory or on assembly, because in both cases the work was equally simple and the class of labour the same.

All operatives were told, on being engaged (Lord Weir continued), that as soon as the factory and the assembly operations were fully organised a system of payment by results would be put in force which would give them an opportunity of substantially increasing their earnings As a firm they had a long and favourable experience—favourable to their men and to themselves—of a well-administered system of payment by results. A recent return of four weeks' working in their factories of about 1,000 engineering craftsmen, semi-skilled men, and labourers showed that while the average standard rate would have been 55*s.* 4*d.* per week, the actual earnings averaged 73*s.* 7*d.* per week. They had no doubt that within a comparatively short time the Weir operatives on "payment by results" would achieve similar performances, which would mean that they would be earning as much as the skilled craftsmen in the building trade. They proposed to give them an opportunity to do so.

The Ministry of Labour states that on March 16, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,219,200—939,000 men, 34,100 boys, 216,000 women and 30,100 girls. On March 9, 1925, the number was 1,220,733—936,500 men, 33,475 boys, 219,857 women and 30,901 girls—and on March 17, 1924, it was 1,094,111—804,696 men, 33,707 boys, 221,624 women and 34,084 girls.

The official organ of the International Association of Machinists states that 10 firms in Cleveland, Ohio, have signed the following agreement:—"It is agreed that machinists shall receive 0·80 dol. per hour for all inside work and 1 dol. per hour for all outside erection work. Forty-four hours shall constitute a week's work. Time and a-half shall be paid for overtime until midnight and double time thereafter, including six legal holidays and all Sunday work. It is further agreed that all men hired by the company shall become members of the organisation one week after commencing work." Negotiations are stated to be in progress with a view to the adoption of the agreement by two other firms.

Mr. Stephen Walsh's Bill to amend the Coal Mines (Minimum Wage) Act of 1912 comes up for second reading to-day. It proposes to extend the 1912 Act to surface workers, and to impose a statutory minimum wage of 12*s.* per shift for adult underground workers on contract or piece rates, of 11*s.* per shift for adult underground workers on time rates, and of 10*s.* per shift on adult surface workers. For boys under 18 years the proposed rates range, according to age, from 4*s.* to 10*s.* per shift underground, and from 3*s.* to 9*s.* per shift on the surface.

The conference between the Shipbuilding Employers Federation and the shipyard trade unions to consider the situation created by foreign competition is to take place in London to-day. In their letter of invitation to the unions to attend such a meeting the employers said:—"The recent placing by a British ship-owning firm of a contract for building five vessels in Germany is a vivid illustration of the severe Continental competition which this country is experiencing. The Shipbuilding Employers' Federation feel sure that this development is causing grave concern to all those who are engaged in the industry, and, further, that there will be general agreement that the whole position should be reviewed and discussed. In these circumstances it is proposed that a joint conference be held, when the situation created by foreign competition and other cognate matters affecting the industry might be discussed by executive representatives of the Employers' Federation and of the trade unions whose members are engaged in shipbuilding and ship-repairing. It is thought that the joint conference should assemble in London at as early a date as possible, and, therefore, I am desired to invite representatives of your union to take part in such conference on Friday, March 27. A similar invitation has been extended to the other unions whose members are employed in shipyards and ship-repairing establishments." The labour organisations, which have accepted the invitation to attend include the Amalgamated Engineering Union, the Boilermakers' Society, and the Shipwrights' Association.

According to the British official report of the recent Metal-workers' Conference at Cologne, Mr. John Hodge said that Great Britain was the only country in the world that had a free-trade fiscal policy. A number of trade union leaders were doubtful, however, that such a policy was beneficial to the country, and were seriously considering whether protection would not alleviate the unemployment trouble. The workers had formed their trade unions to protect themselves against the employer, and also to protect the good against the bad employer. Why not carry that policy further and protect a nation of good employers and workers against the operations of a nation of bad employers? At present Germany was the nation of bad employers and the Conference was considering how best to deal with it. For his own part—and he knew that the majority of his party supported his view—he was sure that the solution of the problem lay in an international eight hours' day, higher wages, and universal Free Trade.

A long resolution passed subsequently by the Conference expressed the opinions (1) that, in the common interest of all people, Labour should demand that commercial treaties be concluded according to the principles of Free Trade, and (2) that the representatives of the workers should be allowed to participate in conferences with regard to commercial treaties as experts with equal rights to those enjoyed by the representatives of capital.

In February unemployed members of the United Patternmakers' Association increased from 742 to 760. That does not look, the General Secretary says, like a spring revival, and, coupled with the shipbuilding order placed in Germany by British shipowners, it suggests that British finance is unlikely to be of much use to British workers.

The relation between the 48-hour week and maximum industrial efficiency is examined in an article in the *International Labour Review* by Dr. P. Sargent Florence, of the Department of Economics in the University of Cambridge. In the view of Dr. Florence the results of a scientific study of the effects of changes in the hours of work, or of introducing rest pauses into working hours, and of variations in output during the working day, all tend to one conclusion. This conclusion is that on the whole the 48-hour week is probably the optimum length of hours, giving for the majority of industrial operations maximum output with minimum accidents, lost time and overhead charges, and permitting an efficient distribution of working hours throughout the week and day. The inquiries on which this conclusion is based were made by the author in factories both in the United States and in Great Britain. The author's own inquiries are compared with the others made by the Industrial Fatigue Research Board and other institutions.

The Hours of Industrial Employment Bill, which has been introduced in the House of Commons by Mr. Buchanan, seeks to limit working hours in accordance with the Washington Convention of the League of Nations. It applies generally to the hours of manual labour, including manufactures, building and repair works, mining, public utility services, and transport undertakings, and would fix maximum hours at eight per day or 48 per week. It would invest the Minister of Labour with considerable discretionary power to exclude from the operation of the Act any branch or department of an undertaking in which the work is "of a commercial character," and any class of undertaking where an agreement has been arrived at between employers and employed, provided he is satisfied that this is a class of work to which the normal limits cannot be reasonably applied, and that on the average the hours do not exceed 48 per week. Overtime is divided into that of a permanent and that of a temporary nature, and the Minister would be authorised to make regulations concerning it. The Bill provides that the minimum payment for overtime shall be time and a quarter, and that all regulations made by the Minister shall be laid before Parliament for 40 days before they become operative. Powers are given to the Minister, or to any Secretary of State, to suspend the Act in cases of emergency.

With a view to the compilation of a record of earnings and hours of labour in 1924 the Ministry of Labour is issuing 400,000 inquiry forms to employers in Great Britain and Northern Ireland. The points upon which information is desired include: (1) the numbers of wage-earners (excluding clerks, typists, commercial travellers, &c.) employed in each of four weeks in 1924; (2) the total amount of wages paid to such workpeople in those weeks, and in the whole of the year 1924; (3) the normal full-time hours of labour in those weeks; (4) the number of workpeople on short time, and the number of hours lost by them; and (5) the aggregate man-hours worked. This information will be less detailed than that obtained in 1906, but arrangements are in contemplation for amplifying it at a later date.

The Ministry proposes also to undertake an inquiry at an early date on the subject of apprenticeship. Information will be sought as to the extent to which systems of apprenticeship at present prevail in each of the principal industries, the sources from which apprentices are obtained, the conditions of service, and the arrangements made for training.

The propagandist efforts of some of Labour's extremists must be, occasionally, somewhat disconcerting to the main body. At Liverpool the other day, for example, Mr. Pollitt stated that the "capitalists'—meaning, of course, the employers—knew that they could not meet the current demands for increased wages and recapture the markets of the world which they had lost. That is, of course, the simple truth, and it ought to encourage employers to get it from Mr. Pollitt's lips. Mr. Pollitt's idea is that it is because employers cannot pay the wages demanded, that they are anxious for industrial peace. In any case, they are anxious for industrial peace, and that is more than can truthfully be said of Mr. Pollitt and the National Minority Movement.

At its two meetings in London last week the Committee of Inquiry into the economic position of the coal-mining industry and the causes of the present depression discussed the question of costs of production of coal in this country as compared with similar costs in Germany and other Continental countries and also in the United States. It is to meet again on Wednesday and Thursday next. The coalowners are represented on the Committee by Mr. Evan Williams, South Wales (chairman); Sir Adam Nimmo, Scotland; Messrs. C. B. Crawshaw, West Yorkshire; Finlay A. Gibson, South Wales; H. E. Allen, North Wales; Reginald Guthrie, Northumberland and Durham; H. Speakman, Lancashire; and Leslie Wright, Derbyshire; with Mr. W. Lea, secretary. The Miners' Federation representatives are: Messrs. Herbert Smith, Yorkshire (president); T. Richardson, Durham (treasurer); A. J. Cook (secretary); P. McKenna, Scotland; Frank Hall, Derbyshire; W. Straker, Northumberland; and P. Pemberton, Lancashire.

INTERMEDIATE CHUTE AND MACERATION SCRAPER FOR SUGAR MILLS.

CONSTRUCTED BY THE MIRRLEES WATSON COMPANY, LIMITED, ENGINEERS, GLASGOW.

FIG. 1.

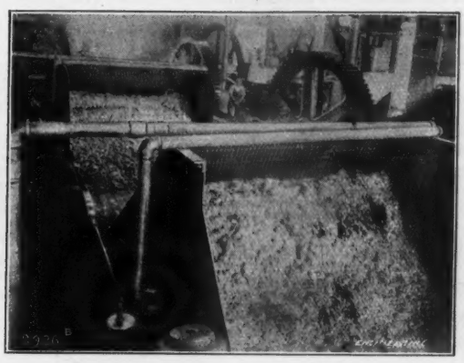


FIG. 2.

Fig. 3.

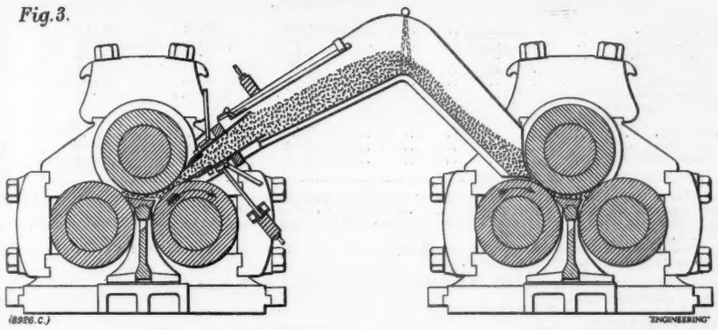
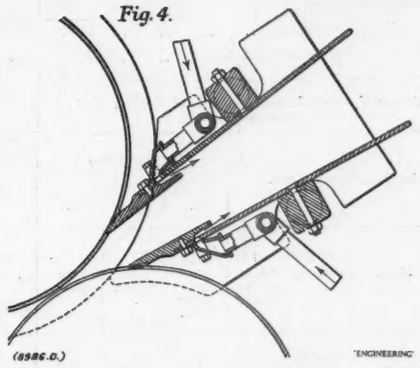


Fig. 4.



INTERMEDIATE CHUTE AND MACERATION SCRAPER FOR SUGAR MILLS.

WHEN sugar cane is crushed in successive sets of mill rollers for the extraction of the sugar juice, it is necessary to adopt some system of conveyors between the various mills or sets of rollers. Usually the conveyance of the megass, or residue resulting from the early crushing processes, is performed with what are termed intermediate carriers, commonly consisting of conveyors built up with slats to catch the megass and carry it forward. During its passage water is sprayed on it, to act as a solvent for the residual sugar juice, most of which will be pressed out in the next set of rollers. These conveyors, because of the multiplicity of their parts, are always liable to get out of order and consequently many people have endeavoured to devise some system of dealing with the megass, which would not necessitate the use of chains, sprockets, friction clutches and all the other moving parts which may fracture and thus hold up the process. In the accompanying illustrations is shown the Meinecke intermediate chute, which serves every purpose of the intermediate carrier and occupies much less space. This equipment, as illustrated, is made by the Mirrlees Watson Company, Limited, of Scotland-street, Glasgow. Messrs. Fawcett, Preston and Co., Limited, of York-street, Liverpool, co-licensees, also manufacture similar apparatus.

The appliance consists of a trough made of mild steel, into which the megass is propelled by the material following through the rollers. In the first part of its progress the megass rises until the crest is reached when it falls over and runs down the chute into the next set of mill rollers. The outward appearance of the chute is illustrated in Fig. 1, where it is shown removed from association with the rollers, while Fig. 2, which depicts a succession of mills and chutes in operation, gives some idea of the condition to which the megass is reduced after continued treatment. The arrangement of a complete Meinecke chute with mills is shown in Fig. 3, while the Ramsay maceration scrapers which are used with it are shown in detail in Fig. 4.

The megass leaving the mill passes between the scraper plates which are both provided with maceration nozzles, in number suited to the length of the rolls. Although not very clearly shown in the various illustrations, the toes of the scrapers are serrated to mesh with the grooves in the top and the discharge rollers. At each side of the chute there are springs and levers to keep the toes of the scrapers in contact with the top roll, while a similar condition for the scraper toe pressing on the discharge roller is obtained by the use of springs and tension bolts, mounted on a strong beam connected to the side caps of the mill. When a narrower opening at the scraper mouth is required, the shafts carrying the scrapers can be pushed towards the rollers by means of the jack screws in the side bracket casting. These screws press against the bearings carrying the scraper shafts and force the scrapers in between the two rollers with a resulting diminution in the opening at the mouth. Usually the gap is between 3 in. and 4 in. and widens out to a value between 6 in. and 9 in. at the end, depending upon the size of the mill and the quantity of cane to be dealt with. Adjustment of the springs holding the scraper toes to the rollers may be made at any time.

The Ramsay maceration scrapers are constructed so that the macerating water is directed on to the megass at the precise moment of expansion, thus ensuring the complete filling of the ruptured cells with water and and not with air. A more thorough absorption is therefore obtained than would be the case with simple spraying. Additional maceration is possible at the crest of the chute where the megass falls. The manner in which the water is introduced at the scrapers may be appreciated by the study of Fig. 4, where it will be seen that the water enters by pipes at the top and bottom, and discharges behind the scraper toes in such a way that it passes with the megass in the direction of its movement and facilitates that action.

One great advantage of this type of intermediate chute is that throughout its course none of the megass can fall into the juice collecting tray of the mill bedplates, as is commonly the case with the slat type of carrier. Nor can the dropping or the accumulation of trash on chains, slats and sprockets of other types of machines, cause trouble. Another point in favour of this equipment is that there are no moving parts, liable to breakage or undue wear. The power required for the operation of this intermediate chute is but small, and before it is long in work the resistance to the motion is reduced, through the polishing which the surface of the trough receives. The arrangement of these chutes is such as to afford good headroom for access to the side rollers and the other parts beside them, while the whole chute can be quickly removed when it becomes necessary to replace a roller. Many installations have already been fitted with the equipment, and it is now in successful operation on mills having rollers 34 in. in diameter and 78 in. length with the mills placed at distances between centres of as much as 22 ft.

MARINE OIL ENGINE TRIALS.

THE second report of the Marine Oil Engine Trials Committee was submitted to a general meeting of the Institution of Mechanical Engineers on Friday last, the 20th instant, as is reported in another part of this issue. The committee in charge of the trials was appointed in 1922 by the Institutions of Mechanical Engineers and Naval Architects, with representatives from the Admiralty and the Institute of Marine Engineers. Admiral Sir George Goodwin is the chairman of the committee, and Mr. W. H. Patchell is vice-chairman.

The second report concerns the tests carried out under their direction on the M.S. Dolius and her engines. The Dolius was built by Messrs. Scotts' Shipbuilding and Engineering Company, Limited (being their Contract No. 520), to the order of Messrs. Alfred Holt and Co., Limited, and was designed to the following general particulars: Length between perpendiculars 400 ft.; length overall, 423 ft.; moulded breadth, 52 ft.; and the mean draught to the bottom of the keel, 25 ft. 9 in. when the vessel is fully loaded and floating on even keel. The displacement when fully loaded is 11,533 tons, and the deadweight capacity 8,100 tons. Under this condition the estimated service speed is 11 knots, the designed aggregate power of the propelling machinery to give this speed being 2,500 shaft horse-power at 120 r.p.m. developed on two shafts. The pair of propellers, each driven direct by one engine, have high-tension brass blades with polished surface, the four blades being bolted to a cast-iron boss. The diameter of the propellers is 12 ft. over the tips, and the pitch of the blades 9 ft. 9 in., the blades being designed of uniform pitch. There is no rake back of the blades. The blade area of each propeller is

48 sq. ft. expanded. The normal direction of rotation, viewed from astern, is outboard.

The engine-room staff of the ship in full sea-going condition was expected to be made up as follows: one chief engineer, seven assistant engineers, two electricians and nine attendants, one of whom would act as donkeyman. The dimensions of the machinery space are: length, 40 ft., plus 7 ft. 6 in. for thrust recess; mean breadth, 52 ft.; and height from tank-top to upper deck, 27 ft. 3¾ in. (moulded).

TABLE IV.—*Weight of Machinery in the Engine-Room.*

Part.	Weight (Tons).
Main engines—Complete with all pipes and fittings, including thrust blocks, but excluding flywheels	290·0
Flywheels	14·5
Shafting and stern gear	75·6
Regenerator boilers, condenser, oil fuel burning plant, steam and steam exhaust pipes	68·6
Auxiliaries, pipes, and fittings—	
Fuel oil system	27·6
Lubricating oil system	8·5
Gas exhaust system	5·1
Pumping system (bilge, ballast and sanitary pumps)	32·8
Electric generator system, complete with air-starting and air-injection pipes and fittings	78·6
Fittings on board—Funnel complete, ventilators, gratings, workshop, lifting gear, tools and outfit	54·0
Spares—Main engines and auxiliaries	13·3
Total	668·6
Water in system	1·2
Water in regenerator boilers	8·0
Water in reserve feed tank	92·0
Lubricating oil in system	5·5
Total	106·7
Total running weight	775·3

TABLE V.—*Schedule of Loads and Speeds, Test Numbers 1 to 12.*

Applied External Load.			Speed (R.P.M.)		
			A.	B.	C.
Nominal.	Torque.	Nearest Brake Load.	Calculated from Propeller Law.	High Speed.	Low Speed.
	Lb.-Ft.	Lb.			
Full torque ..	54,700	4,170	120	135	105
¾ „ ..	41,025	3,130	104	119	89
½ „ ..	27,350	2,080	85	100	70
¼ „ ..	13,675	1,040	60	75	45

In Table IV are given the weights of the propelling machinery of the vessel in running condition, including the propellers and shafting, together with the weights of the auxiliary machinery and other apparatus in the engine-room.

The main propelling engines were built by Messrs. Scotts' Shipbuilding and Engineering Company, Limited, at their engineering works at Greenock, being their Engine No. 592, under licence from Messrs. the Still Engine Company, Limited, Westminster. The engines may be thus designated, "Scott-Still" oil engines. The rating of each engine is 1,250 brake horse-power at 120 r.p.m., the power being developed in four cylinders, acting on the two-stroke single-acting cycle, with four cranks. The method of fuel admission to the cylinders is by mechanical injection (intermittent pressure system) from engine-driven pumps, and the firing of the fuel-charge is obtained by the temperature of compression. Steam generated from the heat recovered from the exhaust gases, and from the heat transmitted through the liners of the combustion cylinders, acts on the underside of the pistons, on the upper side of which the combustion cycles take place. The steam side, moreover, is arranged as a compound-engine, in that the aftermost cylinder is high pressure and exhausts into a receiver from which the remaining three cylinders draw their supply of steam. The overall dimensions in respect of one engine only are: length, 26 ft. over couplings; breadth, 9 ft. 4 in.; and height, from the tank top to the top of the fuel valves, 23 ft. 5¾ in. The engine is bolted directly to the tank top and the height from the centre line of the crankshaft to the top of the fuel valve is 20 ft. 4¾ in.

The construction of the Scott-Still engines is familiar to our readers through the reprint of an exhaustive paper on "The Still Engine for Marine Propulsion," which Mr. Archbald Rennie read before the Institution of Engineers and Shipbuilders in Scotland, which appeared in ENGINEERING, vol. cxiii, pages 275 and 309. In addition to this the actual engines of the Dolius and the arrangement of the machinery in the vessel were described in ENGINEERING, vol. cxvi, page 639, and it is therefore unnecessary to repeat the descriptive matter which appears in the report. On the occasion of our dealing with the first report of the committee, it was pointed out that these publications are of so voluminous a character that it is impossible, in the matter of reproduction, to deal with more than the experimental results obtained in the tests. The arrangement of the present report and the methods of testing the port engine ashore, and the port and starboard main engines and auxiliaries in the ship at sea, follow those adopted in the first report (see ENGINEERING, vol. cxviii, pages 750 and 784). In addition, there was a series of runs at sea at progressive speeds on a measured mile.

The salient dimensions of the port engine were measured for the committee by the Senior Surveyor of the Board of Trade, at Greenock, and the following figures are averaged from the certificate given:—

	In.
Average stroke	36·000
Average bore, combustion cylinders	22·003
Average bore, steam cylinders	22·003
Average diameter of piston rods	6·250

The following quantities were given by the builders:—

	Cub. in.
Clearance volume	1,306
Swept volume to exhaust ports plus clearance volume for one combustion cylinder	11,186

From these particulars the following constants have been calculated:—

Ratio—$\frac{\text{Area of steam cylinder}}{\text{Area of combustion cylinder}}$	0·9193
Indicated horse-power factor for each combustion cylinder for 1 r.p.m. and 1 lb. per square inch	0·03457
Ratio of compression	8·56
Ratio—$\frac{\text{Exhaust port opening}}{\text{Stroke}}$	0·277

The tests ashore were carried out on the port engine only, at Messrs. Scotts' Shipbuilding and Engineering Company's Engine Works at Greenock, the trials being conducted in their marine engine erecting shop, from Tuesday, October 30, to Friday, November 2, 1923. The schedule of loads and speeds, calculated from

TABLE VI.—ANALYSES OF FUEL OIL.

Test Numbers:	1 to 4		5 to 7		8 to 10		11 and 12	
Trade description of fuel	Anglo-American Diesel Oil							
Calorific value (gross), B.Th.U. per lb.	19,573		19,526		19,494		19,440	
Specific gravity at 59 deg. F.	0·863		0·864		0·864		0·863	
Flash point (Pensky-Martin closed test), deg. F.	176		176		172		172	
Burning point, deg. F.	198		198		194		194	
*Viscosity (by Redwood No. 1 viscometer)—								
Seconds at 70 deg. F.	42·2		44·2		42·7		44·7	
Seconds at 150 deg. F.	32·3		33·6		33·1		33·7	
Seconds at 200 deg. F.	30·1		30·8		31·3		30·6	
Engler distillation—								
Temperature of first drop, deg. C.	190		190		190		190	
	Per Cent.	Specific Gravity.	Per cent.	Specific Gravity.	Per Cent.	Specific Gravity.	Per Cent	Specific Gravity.
†Fraction from 200–250 deg. C.	33·7	0·844	33·9	0·842	34·5	0·843	33·4	0·841
†Fraction from 250–300 deg. C.	41·5	0·860	41·1	0·861	40·7	0·862	42·7	0·861
†Fraction from 300–350 deg. C.	16·9	0·878	16·8	0·875	17·0	0·878	15·8	0·870
Residue	7·9	0·885	8·2	0·902	7·8	0·884	8·1	0·884
Water content	Trace, small drops discernible.		Nil.		Very slight trace.		Slight trace.	
Ultimate analysis—								
Carbon, per cent.	85·90		86·23		86·40		85·84	
Hydrogen, per cent.	12·85		12·95		13·02		12·96	
Sulphur, per cent.	0·43		0·52		0·42		0·25	
Nitrogen, per cent.	0·02		0·02		0·06		0·05	
Oxygen and errors, per cent.	0·80		0·28		0·10		0·90	
Carbon residue and free carbon, per cent. (Determined by the method of the Institution of Petroleum Technologists.)	0·17		0·22		0·20		0·20	
Ash, per cent.	Nil.		Nil.		Nil.		Nil.	
Soft asphaltum, per cent.	0·04		0·07		0·10		0·07	
Hard asphaltum, per cent.	0·14		0·13		0·16		0·16	

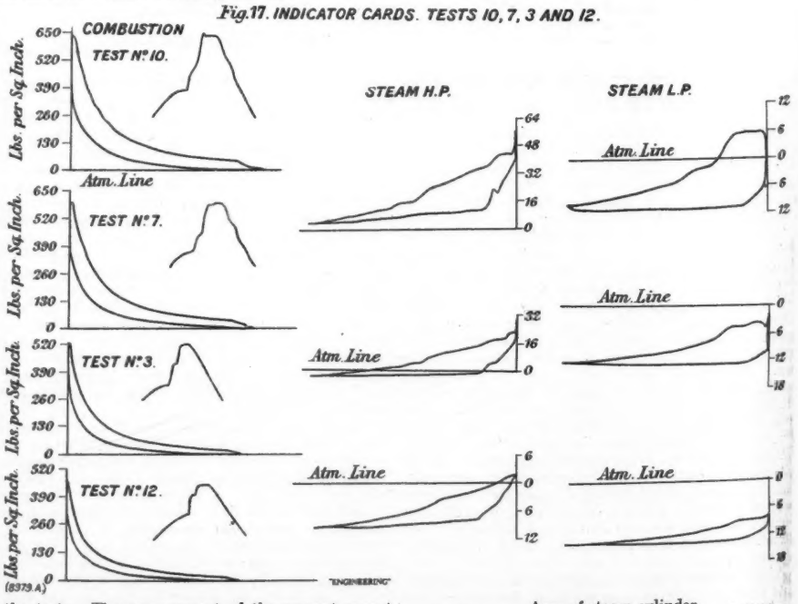
* The oil was so fluid at 32 deg. F. that no reliable figures were obtainable with a No. 2 viscometer.

† In each sample the distillate from 32–392 deg. amounted only to a few drops.

NOTE:—*Cold Test.*—In the case of each of the foregoing samples there was observed to be practically no change at a temperature of − 4 deg. F.

Impurities.—The four samples mixed with pure benzene were allowed to settle for more than a week. No impurities were observed to have settled out during this time.

Fig. 17. INDICATOR CARDS. TESTS 10, 7, 3 AND 12.



the simple approximation to propeller law,* in accordance with which the trials ashore of the port engine were conducted, is shown in Table V. The constant in the relation, torque = constant × (revolutions per minute)², being determined from the condition of rated full power of the engine, namely, 1,250 brake horse-power at 120 r.p.m. For a given load on the engine, the speed calculated from the foregoing relation is referred to as A, that at 15 r.p.m. above the calculated speed as B, and that at 15 r.p.m. below as C.

Several tests, additional to the schedule just described, were carried out; these were: A test with the engine developing power in excess of its rating; a test to determine the power absorbed by friction

Fig. 18. MECHANICAL EFFICIENCY. MEAN EFFECTIVE PRESSURE: (a) INDICATED: (b) BRAKE EQUIVALENT.

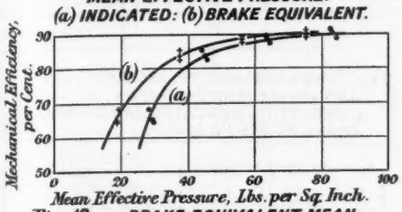


Fig. 19. BRAKE EQUIVALENT MEAN EFFECTIVE PRESSURE, OR TORQUE. MEAN INDICATED PRESSURE.

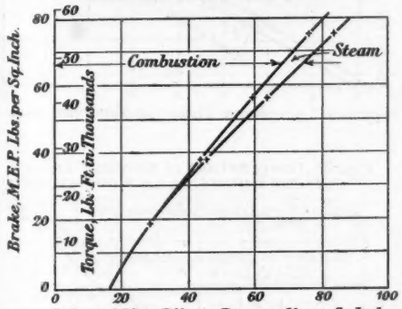
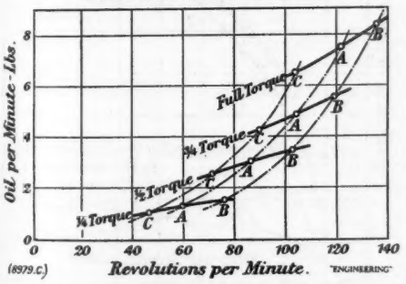


Fig. 20. FUEL CONSUMED PER MINUTE. SPEED AND TORQUE CURVES.



in the engine; and tests to determine the slowest speeds at which the engine would run. Details of these tests are given towards the end of the report.

The procedure described in the former report was closely followed throughout the tests, namely, the attendants were informed what brake-load and speed would be required for a particular test, no other conditions as to running being laid down. By means of preliminary observations it was ensured that a sufficiently long stabilising period had elapsed, before any test was commenced. The timing of the fuel admission to the cylinders was that at which it was intended the engine should run at sea. The quantity of fuel passing to the engine was measured, by volume, using one or other of a pair of vertical cylindrical tanks (of cast-iron, smooth bored internally) graduated to read direct in lb. of water. Either tank, by means of a three-way cock, could be put into communication with the suction of the engine fuel-pumps. The tanks were filled at the top from an elevated service tank, through a supply pipe, the discharge of which was easily visible. Readings of the level of the fuel in the tank in use, were made at 5- or 10-minute intervals from the signal to start in order to check the regularity of consumption during each test. No intermediate readings of level were lost during replenishment of a tank, as that not previously in use, was brought into action at a convenient time signal. Leakage at the fuel-pump plungers was weighed at the conclusion of each test and deducted from the amount recorded at the measuring tank. During the trials no leakage into the measuring tanks through the supply pipe was observed, also the three-way cock was ascertained to be satisfactory. A similar pair of cylindrical tanks was arranged for measurement of the fuel supply to the burners (when in use) in the combustion chamber of the main regenerator. The tanks were replenished from the service tank mentioned above. At the conclusion of the tests the calibration of each tank was verified.

The brake used was made by Messrs. Heenan and Froude, Worcester, and was of the type in which the force necessary to keep the stator in equilibrium is weighed on a simple steelyard such that a force of 500 lb. exerted by the brake stator is balanced by the 100 lb. jockey weight when placed at the free end of the steelyard. The weights used were compared with standards provided by the firm and were found to be satisfactory, also the dimensions of the brake were measured.

Each engine was fitted with a Siemens, 6-point dial totally enclosed pyrometer indicator, the thermo-couples for use with this instrument being iron-constantan. The couples were arranged at the following five points.—(1) at exit of the exhaust gases from cylinder No. 4; (2) at exit from the primary regenerator of the same cylinder; (3) at entry to the water drum of main regenerator; (4) at entry to the feed-water heater; (5) at exit from the feed-water heater.

Messrs. Siemens provided a correction for the observed reading from each couple. The corrected temperatures are plotted in Fig. 25, except (1) above, which indicated temperatures considerably lower than (2) and (3) and which have therefore been excluded.

The flow in the water system, due only to thermal action in changing the density of the water, and being under the full pressure of the steam supply, presented considerable difficulty in its measurement, in that no restriction to motion in the pipes was permissible, and in that the velocity of the water was too low to admit of any instrument depending on impact being used. A Venturi meter to suit the special needs of the case was designed at the National Physical Laboratory. The instrument was arranged for measurement of flows in either direction, the converging and diverging cones being of equal taper. The diameter of the throat was 3·1 in., for a full pipe bore of 3·5 in. The pressure differences between main and throat were observed in a U-tube containing carbon tetra-chloride (Density = 99·8 lb. per cubic foot). Assuming a constant (0·96) to cover friction and other losses in the

TABLE X.—INDICATOR CARDS, MEAN PRESSURES AND INDICATED HORSE-POWER.

(*a*) Combustion side and (*b*) steam side.

Test Number:	B 9	A 10	C 8	B 5	A 7	C 6	B 1	A 3	C 2	B 4	A 12	C 11
(*a*) Combustion side:—												
Mean indicated pressure, lb. per square inch	—	—	—	—	—	—	—	—	—	—	—	—
Cylinder No. 1, forward	76·0	75·9	76·8	64·0	60·1	62·6	44·9	46·7	49·5	33·2	36·6	41·5
,, 2	74·7	77·0	74·1	62·8	59·8	60·1	43·1	40·9	41·9	27·2	26·0	26·4
,, 3	76·4	77·4	81·5	53·6	58·2	58·8	46·5	44·3	38·5	22·3	26·7	27·0
,, 4, aft	76·1	76·1	77·7	58·4	57·7	58·5	40·7	42·8	44·5	30·8	29·2	22·8
Average, all cylinders	75·8	76·6	77·5	59·7	58·9	60·0	43·8	43·7	43·6	28·4	29·6	29·4
Indicated horse-power	1,420	1,290	1,177	987	851	747	622	522	428	298	245	187
Thermal equivalent of I.H.P. for one minute, B.Th.U.	60,250	54,700	47,300	41,800	36,100	31,700	26,400	22,150	18,200	12,630	10,390	7,930
(*b*) Steam side:—												
Mean indicated pressure (referred to area of combustion cylinder) lb. per square inch	—	—	—	—	—	—	—	—	—	*	*	*
Cylinder No. 1, forward	5·7	5·9	5·8	3·8	3·5	3·0	1·8	1·3	0·8	—	—	—
,, 2	6·7	6·4	6·2	4·2	3·7	3·0	1·8	1·4	1·0	—	—	—
,, 3	5·6	5·0	5·1	3·6	3·1	2·7	1·6	1·2	0·8	—	—	—
,, 4, aft, high pressure	10·5	10·3	10·5	8·0	7·2	5·8	3·6	2·5	1·4	—	—	—
Average, all cylinders	7·1	6·9	6·9	4·9	4·4	3·6	2·2	1·6	1·0	—	—	—
Indicated horse-power	133	116	99	81	63	45	31	19	10	—	—	—
Thermal equivalent of I.H.P. for one minute, B.Th.U.	5,650	4,920	4,200	3,440	2,670	1,910	1,310	810	420	—	—	—
Total I.H.P. Combustion and Steam	1,553	1,406	1,216	1,068	914	792	653	541	438	298	245	187

* Steam shut off.

TABLE XI.—(*a*) BRAKE; (*b*) FRICTION; AND (*c*) COMBUSTION BRAKE HORSE-POWER.

Test Number:	B 9	A 10	C 8	B 5	A 7	C 6	B 1	A 3	C 2	B 4	A 12	C 11
(*a*) Absorption Dynamometer:—												
Brake horse-power	1,415	1,271	1,085	935	818	704	539	453	373	202	157	121
Brake mean effective pressure, lb. per square inch	75·4	75·4	75·4	56·6	56·6	56·6	38·0	38·0	38·0	19·3	19·0	19·0
Thermal equivalent of B.H.P. for one minute, B.Th.U.	59,900	53,900	46,000	39,600	34,700	29,820	22,840	19,200	15,800	8,560	6,650	5,130
(*b*) Friction:—												
Friction horse-power (total I.H.P. —B.H.P.)	138	135	131	133	96	88	114	88	65	96	88	66
Friction mean effective pressure, lb. per square inch	7·4	8·0	9·1	8·0	6·6	7·1	8·0	7·4	6·6	9·2	10·6	10·3
Thermal equivalent of F.H.P. for one minute, B.Th.U.	5,850	5,720	5,550	5,640	4,070	3,740	4,840	3,740	2,760	4,070	3,740	2,800
(*c*) Combustion brake horse-power:—												
Combustion I.H.P.—Friction horse-power	1,282	1,155	986	854	755	659	508	434	363	202	157	121
Thermal equivalent of C.B.H.P. for one minute, B.Th.U.	54,400	48,980	41,750	36,160	32,030	27,960	21,560	18,410	15,440	8,560	6,650	5,130

TABLE XII.—FUEL QUANTITIES AND DEDUCTIONS.*

Test Number:	B 9	A 10	C 8	B 5	A 7	C 6	B 1	A 3	C 2	B 4	A 12	C 11
Quantity per hour, lb.	500·0	447·6	391·1	334·0	293·1	256·5	207·3	181·9	151·3	94·9	79·7	63·7
Quantity per minute, lb.	8·333	7·460	6·519	5·567	4·885	4·275	3·455	3·035	2·522	1·582	1·328	1·062
Temperature, deg. F.	56·7	56·9	55·9	58·6	58·6	59·7	60·0	61·0	62·5	60·7	58·0	58·0
Weight per B.H.P. per hour, lb.	0·354	0·353	0·360	0·357	0·358	0·364	0·385	0·401	0·406	0·469	0·508	0·527
Weight per I.H.P. per hour, lb.	0·319	0·322	0·322	0·324	0·326	0·325	0·324	0·325	0·322	0·322	0·321	0·335
Heat carried in fuel per minute, B.Th.U.	162,200	145,200	127,000	108,800	95,400	83,500	67,500	59,300	49,350	30,950	25,800	20,650
Weight of CO_2 formed per minute, lb.	26·35	23·60	20·60	17·60	15·43	13·52	10·92	9·60	7·98	5·00	4·20	3·36
Weight of steam formed per minute, lb.	9·75	8·74	7·64	6·53	5·72	5·00	4·04	3·55	2·95	1·85	1·55	1·24
Theoretical weight of air required per minute for combustion, lb.	120·8	108·2	94·5	80·8	70·8	62·0	50·1	44·0	36·6	23·0	19·3	15·4

* For main engine and main engine-driven auxiliaries only.

* Torque = constant × speed² assuming constant slip. See ENGINEERING, vol. cxviii, p. 751.

converging cone of the instrument, the expression for the discharge is—

$$Q = 69{\cdot}1 \sqrt{h} \,.\, w \text{ lb. of water per minute.}$$

where w is the density of water (lb. per cubic foot) at its temperature of exit from the water-drum of the main regenerator, and h is the difference in inches of the level of the indicating fluid in the two limbs of the U-tube.

The total quantity of water in the system is made up as follows :—

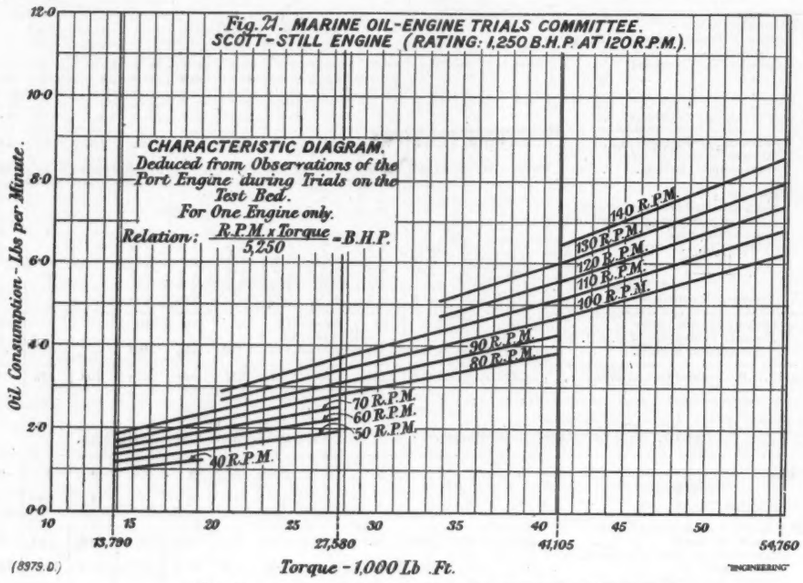
(a) A sensibly constant quantity made up of water in the water-drum, in the pipes communicating with the engine, and in the engine jackets, &c., and

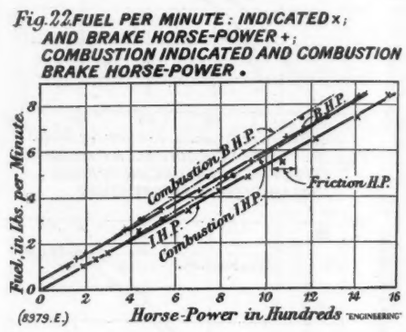
(b) Quantities which themselves fluctuate, but which, were there no loss, are constant in sum, namely, water in the steam-drum, in the two condensate tanks and in the feed-tank.

The estimated loss of water from the system over

TABLE XIII.—MECHANICAL AND THERMAL EFFICIENCIES.

Test Number:	B 9	A 10	C 8	B 5	A 7	C 6	B 1	A 3	C 2	B 4	A 12	C 11
Mechanical efficiency $\frac{\text{B.H.P.}}{\text{total I.H.P.}}$ ..	91·1	90·5	89·4	87·5	89·6	88·8	82·6	83·8	85·2	67·8	64·1	64·7
Combustion mechanical efficiency $= \frac{\text{combustion B.H.P.}}{\text{combustion I.H.P.}}$	90·4	89·6	88·3	86·5	88·8	88·2	81·7	83·1	84·8	67·8	64·1	64·7
Thermal efficiency, total I.H.P. basis ..	40·9	40·5	40·5	40·3	40·0	40·2	40·3	40·2	40·5	40·5	40·6	39·0
Thermal efficiency, combustion I.H.P. basis	37·0	37·0	37·2	37·4	37·5	37·8	38·4	38·6	39·2	40·5	40·6	39·0
Thermal efficiency, B.H.P. basis	36·9	37·1	36·2	36·4	36·4	35·7	33·9	32·4	32·1	27·7	25·8	24·8
Thermal efficiency, combustion B.H.P. basis	33·5	33·5	32·9	33·3	33·6	33·5	31·9	31·0	31·3	27·7	25·8	24·8
Efficiency ratio $= \frac{\text{thermal efficiency, total I.H.P. basis}}{\text{efficiency of ideal engine}}$	0·818	0·810	0·810	0·806	0·800	0·804	0·806	0·804	0·810	0·810	0·812	0·780





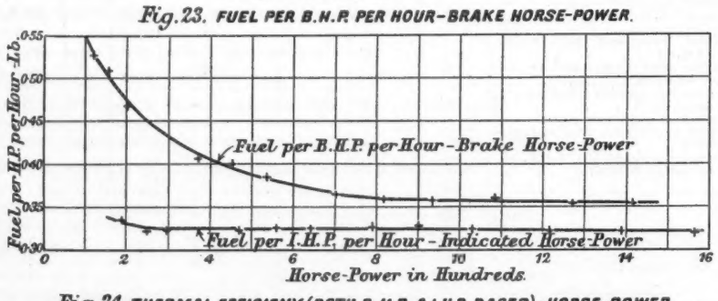


Fig. 23. FUEL PER B.H.P. PER HOUR-BRAKE HORSE-POWER.
Fuel per B.H.P. per Hour - Brake Horse-Power
Fuel per I.H.P. per Hour - Indicated Horse-Power
Fuel per H.P. per Hour - Lb.
Horse-Power in Hundreds.

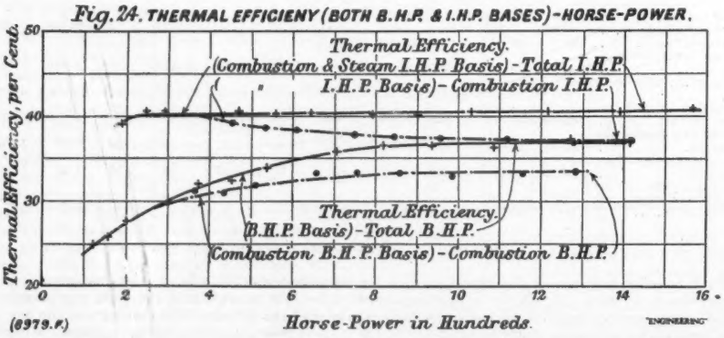


Fig. 24. THERMAL EFFICIENY (BOTH B.H.P. & I.H.P. BASES)-HORSE-POWER.
Thermal Efficiency. (Combustion & Steam I.H.P. Basis) - Total I.H.P.
I.H.P. Basis) - Combustion I.H.P.
Thermal Efficiency. (B.H.P. Basis) - Total B.H.P.
Combustion B.H.P. Basis) - Combustion B.H.P.
Thermal Efficiency, per Cent.
Horse-Power in Hundreds.
(8979.F.)

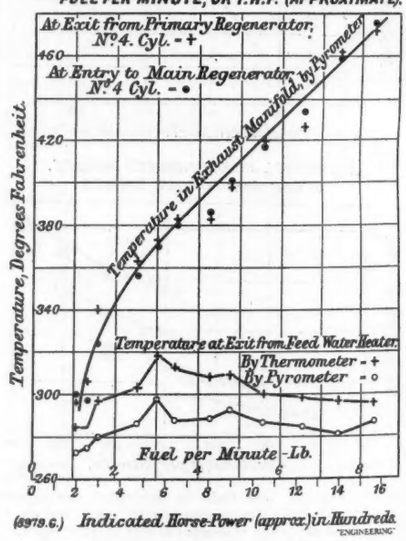
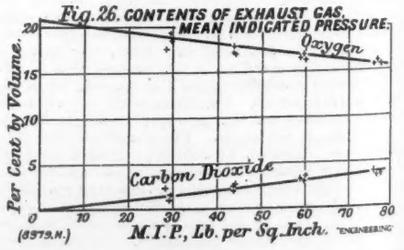


Fig. 25. TEMPERATURE OF EXHAUST GASES - FUEL PER MINUTE, OR I.H.P. (APPROXIMATE).
At Exit from Primary Regenerator, No. 4. Cyl. - +
At Entry to Main Regenerator, No. 4 Cyl. - •
Temperature in Exhaust Manifold, by Pyrometer
Temperature at Exit from Feed Water Heater.
By Thermometer - +
By Pyrometer - o
Fuel per Minute - Lb.
Temperature, Degrees Fahrenheit.
Indicated Horse-Power (approx) in Hundreds.
(8979.G.)



a period is, therefore, the algebraic sum of :—(i) Change of water level in the steam-drum; (ii) difference between the sum of the readings of both condensate tanks at beginning and end of period; (iii) change of water level in the feed-tank.

Samples of exhaust gas were withdrawn at a point in the manifold before entry to the water-drum of the main regenerator, and were collected over mercury as described in the First Report. A few of the samples were collected in rubber-stoppered containers, but the corrected analyses of these, which are marked * in the tabulated results, have in every case been considered to be admissible. All the other samples were collected in tubes provided with glass stop-cocks. The analyses of the exhaust gases and the deductions therefrom are recorded in Tables XVIA and XVIB.

All the analyses were carried out at H.M. Fuel Research Station, Greenwich, the results of the analysis of the samples of fuel oil collected on each of the four days of the trial being given in Table VI. To simplify the calculations, average figures from the ultimate analysis have been adopted, namely :—

Component.	Per cent.
Carbon	86·09
Hydrogen	12·95
Sulphur	0·40
Nitrogen	0·04
Oxygen	0·52
	100·00

From the foregoing average analysis, the following quantities have been calculated in respect of the perfect combustion of 1 lb. of fuel :—

		lb.
(*a*)	Weight of CO_2 formed	3·16
(*b*)	,, Steam ,, ...	1·17
(*c*)	,, SO_2 ,, ...	0·008
(*d*)	Weight of oxygen required for (*a*)	2·30
(*e*)	,, ,, ,, (*b*)	1·04
(*f*)	,, ,, ,, (*c*)	0·004
(*g*)	Theoretical total weight of air required	14·50

and friction horse-powers as well as the combustion brake horse-power are stated in Table XI. Curves connecting various sets of observations are also shown. In general these may be regarded as self-explanatory. The "Characteristic Diagram" (Fig. 21) of the engine (from which the torque exerted for any given fuel consumption and engine speed can be read off) has been derived by a simple construction from Fig. 20. In Fig. 22 the fuel consumptions in pounds per minute to bases of brake and indicated horse-power are plotted.

The following curves, &c., are also reproduced, namely :—Fig. 17, Indicator cards—Power cylinders—gas temperature—Fuel per minute or indicated horse-power (approximate). Fig. 26, Exhaust gas composition—Mean indicated pressure. Fig. 27, Fuel per minute or indicated horse-power (approximate)—Rate of flow of circulating water, weight of steam generated, heat recovered in regenerative system.

TABLE XVIa.—Exhaust Gas Analyses and Deductions.

Test Number	B 9	A 10	C 8	B 5	A 7	C 6 *	B 1 *	A 3 *	C 2 *	B 4 *	A 12	C 11
Analysis of dry gas by volume—												
Carbon dioxide, CO_2	3·85	3·45	3·76	2·90	3·23	3·40	2·72	2·67	2·12	2·45	1·70	1·00
Carbon monoxide, CO	0·10	0·15	0·10	0·03	0·05	—	0·15	0·05	0·10	—	0·20	0·15
Oxygen, O_2	15·70	16·00	15·70	16·82	16·47	16·27	17·06	17·15	17·87	17·56	18·50	19·40
Nitrogen, N_2	80·35	80·40	80·44	80·25	80·25	80·33	80·07	80·13	79·91	79·99	79·60	79·45
Mean specific heat of dry gas, B.Th.U. per lb. per 1 deg. F.	0·233	0·232	0·232	0·233	0·233	0·233	0·232	0·233	0·232	0·232	0·232	0·233
For 1 lb. of carbon in fuel—												
Weight of dry exhaust gas, lb. ..	61·7	67·5	63·1	82·8	74·4	71·5	84·7	89·4	109·0	99·0	127·3	209·5
Weight of dry gas + steam generated, lb.	63·06	68·86	64·46	84·16	75·76	72·86	86·06	90·76	110·36	100·36	128·66	210·86
Weight of dry air supplied, lb. ..	61·9	67·7	63·3	83·0	74·6	71·7	84·9	89·6	109·2	99·2	127·5	209·7
For 1 lb. of fuel consumed—												
Weight of dry air supplied, lb. ..	53·2	58·3	54·5	71·4	64·2	61·7	73·1	77·3	94·0	85·3	109·7	180·3
Weight of air in excess of that required for combustion, lb. ..	38·7	43·8	40·0	56·9	49·7	47·2	58·6	62·8	79·5	70·8	95·2	165·8
Weight of moisture in air supplied, lb.	0·38	0·42	0·39	0·51	0·45	0·44	0·58	0·55	0·75	0·61	0·77	1·26
Weight of atmospheric air supplied, lb.	53·58	58·72	54·89	71·91	64·65	62·14	73·68	77·85	94·75	85·91	110·47	181·56

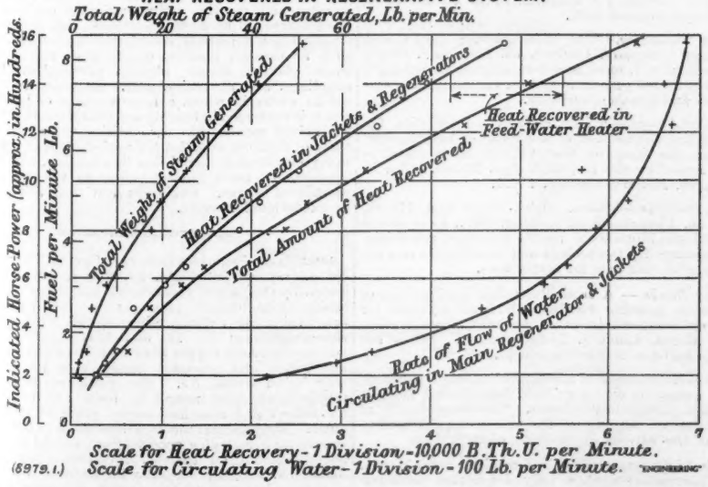
* Adjusted analysis.

TABLE XVIb.—Further Deductions from Exhaust Gas Composition.*

Test Number :	B 9	A 10	C 8	B 5	A 7	C 6	B 1	A 3	C 2	B 4	A 12	C 11
All quantities in respect of one minute's duration—												
Weight of atmospheric air supplied, lb.	446	438	358	401	315	266	254	236	239	136	147	193
Weight of dry exhaust gas, lb.	442	434	354	398	312	263	252	234	237	135	146	191
Heat carried away in dry exhaust gas (reckoned above dry bulb temp.) B.Th.U.	24,000	23,050	19,200	22,200	17,500	14,700	14,100	13,600	12,900	7,240	7,520	9,850
Weight of steam formed by combustion, lb.	9·75	8·74	7·64	6·53	5·72	5·00	4·04	3·55	2·95	1·85	1·55	1·24
Total heat carried away in above (reckoned on basis of saturation at 14·7 lb. per sq. in.), B.Th.U.	11,320	10,130	8,880	7,620	6,660	5,830	4,720	4,150	3,430	2,140	1,800	1,430
Weight of moisture in air supplied, lb. ..	3·16	3·08	2·50	2·82	2·18	1·87	1·98	1·67	1·86	0·95	1·01	1·34
Superheat carried away in above (reckoned above dry bulb temp. and on basis of saturation at dew point), B.Th.U. ..	342	330	272	316	244	210	222	194	204	102	104	138
Total amount of heat carried away in exhaust gas, B.Th.U.	35,662	33,510	28,352	30,136	24,404	20,740	19,042	17,944	16,534	9,482	9,424	11,418

* The Final Temperature of the exhaust gas used in this Table has been taken, for each test, as the mean of the readings of the pyrometer and the thermometer placed in the exit from the feed-water heater.

Fig. 27. FUEL PER MINUTE OR I.H.P. (APPROXIMATE)-RATE OF FLOW OF CIRCULATING WATER-WEIGHT OF STEAM GENERATED. HEAT RECOVERED IN REGENERATIVE SYSTEM.



(5979.1.)

The results given for the tests ashore are recorded as the averages of the periodical observations, duly corrected, where required, in respect of the subsequent calibration of the instruments used. The deductions made follow immediately from the observed particulars. Sufficient information is recorded to permit of further deductions being made. In Table X the deductions from the indicator cards are given, while the brake Tests 10, 7, 3 and 12. Fig. 18, Mechanical efficiency—Mean effective pressure (*a*, indicated; and *b*, brake equivalent). Fig. 19, Brake equivalent mean effective pressure or torque—Mean indicated pressure. Fig. 23 Fuel per indicated horse-power and per brake horse-power per hour—Horse-power. Fig. 24, Thermal efficiency (both indicated horse-power and brake horse-power bases)—Horse-power. Fig. 25, Exhaust

The arrangement of the Tables of observations and deductions and the curves plotted therefrom are substantially in the order followed in the First Report. There are, however, a few points upon which some explanation may be desirable :—The friction horse-power is the difference between the total indicated horse-power (combustion and steam) and the brake horse-power absorbed by the dynamometer. By subtracting the friction horse-power thus obtained from the combustion indicated horse-power a quantity is derived which represents the brake horse-power that combustion alone would develop unassisted by steam. To this quantity the title "combustion brake horse-power" has been given. In other words, the combustion side of the engine is assumed to overcome all the frictional resistances and to give the combustion brake horse-power at the brake, then the effect of the assistance of the steam is to add its power (indicated horse-power steam) to the combustion brake horse-power to make up the observed brake horse-power. The object of this conception is to enable comparisons to be made with the performances of other engines working without the assistance of steam, and, for the purposes of the present Report, to enable the thermal equivalents of the work done to be subdivided in the thermal balance sheets. Mechanical and thermal efficiencies have been calculated in respect of the combustion brake horse-power, and are recorded along with the other efficiencies in Table XIII.

The tabulated values of the total indicated horse-power-hours and thermal efficiency have been obtained, using indicated horse-powers corrected to the fair line, fuel per minute—total indicated horse-power, in Fig. 22. The values of thermal efficiency (combustion indicated horse-power basis) have been obtained using figures corrected similarly. In calculating the deductions from the fuel quantities (Table XII), no correction has been made for the fuel equivalent of the electrical input to the motors on the scavenge-air blower and the steam-valve gear pump respectively. On the basis of the performance of the electrical generating machinery during the trials at sea, the amount to be added to the observed hourly fuel consumption (for main engine and main engine-driven auxiliaries) to obtain the hourly fuel consumption for all purposes is the horse-power absorbed in both motors multiplied by 0·53.

Pending a decision from the Committee on Tabulating the Results of Heat Engine and Boiler Trials, the thermal efficiency of the standard of comparison for these tests has been taken as 0·50; the necessary correction can be made later. The efficiency ratio, on this basis, is shown for each test in Table XIII.

The temperature and pressure of the steam entering the turbine and the pressure at entry to the condenser being known, the heat drop per pound of steam passing through has been scaled off the Mollier diagram, from which also the quality of the "stuff" leaving the turbine can be read off directly. The total amount of heat abstracted per minute from the steam in the turbine is the above heat drop multiplied by the rate of discharge from the condenser air pump.

The arrangement of the balance sheets (Table XXII) in three self-contained parts has been adopted as representing the most natural way to regard the performance of the whole plant. Their construction may be, briefly, described thus :—

(1) The combustion of the fuel develops combustion indicated horse-power which is split into combustion brake horse-power and friction horse-power (shown in italics in Table XXII), and the balance is rejected from the cycle.

(2) The heat rejected from the combustion cycle is recovered, in part, in the regenerative system, which includes the primary and main regenerators, and the feed-water heater (both shown in italics in Table XXII); part is irrecoverably lost in the heat carried away in the exhaust gases (a calculable amount, Table XVIb), which leave the feed-water heater for the funnel, and the balance is a loss due to radiation from the surfaces of the regenerators, feed-water heater, cylinder jackets and pipes, but not from the surfaces of steam cylinders, piping, turbine, and condenser.

(3) The total amount of heat recovered from that rejected from the combustion cycle is placed to the credit of the steam cycle and is accounted for thus :—By the indicated work done in the steam cylinders; by the heat drop through the turbine, and by the heat carried away in the condenser circulating water. The balance, shown as unaccounted for, includes radiation losses from the surfaces of the steam cylinders, from the turbine and from the condenser, as well as experimental errors.

In preparing the balance sheets no account has been

MARINE OIL ENGINE TRIALS.

TABLE XXII.—THERMAL BALANCE SHEETS (ALL QUANTITIES IN B.TH.U. PER MINUTE).

I. Combustion Cycle. II. Waste Heat Recovery. III. Steam Cycle.

Test Number:	B 9	A 10	C 8	B 5	A 7	C 6	B 1	A 3	C 2	B 4	A 12	C 11
I.—COMBUSTION CYCLE.												
To heat in fuel	162,200	145,200	127,000	108,800	95,400	83,500	67,500	59,300	49,350	30,950	25,800	20,650
By thermal equivalent of—												
Combustion brake horse-power	*54,400*	*48,980*	*41,750*	*36,160*	*32,030*	*27,960*	*21,560*	*18,410*	*15,440*	*8,560*	*6,650*	*5,130*
Friction horse-power ..	*5,850*	*5,720*	*5,550*	*5,640*	*4,070*	*3,740*	*4,840*	*3,740*	*2,760*	*4,070*	*3,740*	*2,800*
Total = Combustion indicated horse-power	60,250	54,700	47,300	41,800	36,100	31,700	26,400	22,150	18,200	12,630	10,390	7,930
By heat rejected from combustion cycle	101,950	90,500	79,700	67,000	59,300	51,800	41,100	37,150	31,150	18,320	15,410	12,720
	162,200	145,200	127,000	108,800	95,400	83,500	67,500	59,300	49,350	30,950	25,800	20,650
II.—WASTE HEAT RECOVERY.												
To heat rejected from combustion cycle	101,950	90,500	79,700	67,000	59,300	51,800	41,100	37,150	31,150	18,320	15,410	12,720
By heat recovered in—												
Jackets, primary and secondary regenerators	*48,155*	*39,400*	*33,880*	*25,110*	*20,080*	*18,640*	*12,610*	*10,310*	*6,970*	*5,070*	*4,020*	*2,890*
Feed water heater	*14,540*	*11,300*	*9,900*	*7,560*	*6,040*	*5,140*	*2,260*	*1,950*	*1,770*	*1,270*	—	*400*
Total heat recovered ..	62,695	50,700	43,780	32,670	26,120	23,780	14,870	12,260	8,740	6,340	4,020	3,290
By heat carried away in the exhaust gases leaving the feed water heater	35,662	33,510	28,352	30,136	24,404	20,740	19,042	17,944	16,534	9,482	9,424	11,418
„ radiation..	3,593	6,290	7,568	4,194	8,776	7,280	7,188	6,946	5,876	2,498	1,966	− 1,988
	101,950	90,500	79,700	67,000	59,300	51,800	41,100	37,150	31,150	18,320	15,410	12,720
III.—STEAM CYCLE.												
To heat recovered	62,695	50,700	43,780	32,670	26,120	23,780	14,870	12,260	8,740	6,340	4,020	3,290
By thermal equivalent of steam indicated horse-power	5,650	4,920	4,200	3,440	2,670	1,910	1,310	810	420	—	—	—
„ heat drop through turbine	4,630	3,450	2,180	1,020	630	306	64	14	—	—	—	—
„ heat rejected to condenser cooling water ..	45,700	37,500	28,000	20,800	14,160	7,000	6,780	4,930	3,020	1,292	1,367	1,353
„ radiation..	6,715	4,830	9,400	7,410	8,660	14,564	6,716	6,506	5,300	5,048	2,653	1,937
	62,695	50,700	43,780	32,670	26,120	23,780	14,870	12,260	8,740	6,340	4,020	3,290

taken of the heat passing from the combustion side through the pistons to the steam, which is thereby re-heated. No attempt at an experimental or analytical estimate of this quantity of heat has been made.

A trial of the engine developing power in excess of its rating was conducted. The power was developed with the assistance of additional steam generated by the combustion of fuel at the auxiliary burners in the main generator. The analysis of the fuel used in the combustion cylinders and at the burners is shown in the last column of Table VI. The load on the brake and the corresponding speed were calculated from the relation: Torque = constant × speed², used in the compilation of Table V.

A friction test was carried out immediately after the conclusion of the full power trial. The water was emptied from the brake and the engine was made to run on the residual steam alone, the cylinders being compounded.

The average speed over the period of the test, which lasted 10 mintutes, was 104 r.p.m. Due to friction in the glands of the brake, it was found necessary to apply a load of 75 lb. to balance the drag; this load is equivalent to 1·4 lb. per square inch m.e.p.

The engine friction reduced to m.e.p. is the difference between the mean indicated pressure (average) from the three sets of cards taken, and the equivalent of the friction in the brake. The average mean indicated pressure from the 12 cards is 8·1* lb. per square in chand the equivalent m.e.p. of friction is, therefore, 6·7 lb. per square inch (*cf.* Table XI, Test 7.)

A slow-running test was carried out on November 2, at the conclusion of the foregoing trial at high power, and was divided into two parts, namely:—

(1) The brake being full of water, but carrying no load, with the combustion cylinders, only, in operation, the lowest speed maintained was 37·2 r.p.m.

(2) The brake being emptied and carrying no load,† with steam only operating in the four cylinders, not compounded, the lowest speed maintained was 20·4 r.p.m.

In each of the above cases the speed recorded as the lowest, is the average maintained over a period of 5 minutes. At the conclusion of both tests the engine was accelerated up to full speed.

(To be continued.)

* Referred to area of combustion cylinder, that is, m.e.p. determined from cards × 0·9193.

† Except that due to the friction in the glands of the brake.

CATALOGUES.

Trailers, Trucks, &c.—A catalogue of trailers, light and heavy lorries, rail and hand trucks, &c., has come to hand from Messrs. R. A. Dyson and Co., Ltd., 80, Grafton-street, Liverpool.

Steam Engines.—Messrs. Dickinson and Burne, Limited, Arbroath, have sent us a copy of a circular announcing a reduction in the prices of their vertical steam engines of all types.

Lifts.—A copy of the house journal of Messrs. Marryat and Place and Marryat and Scott, Limited, 28, Hatton Garden, E.C. 1, has come to hand, containing articles on electric lifts and kindred matters.

Motor-Converter.—General and detail illustrations of a 1,000-kw. La-Cour motor-converter, with brief descriptive text, are given in a special catalogue received from the A.C.E.C. Company of Belgium, whose London office is at 56, Victoria-street, S.W.

Railway Signalling.—The Westinghouse Brake and Saxby Signal Company, Limited, 82, York road, King's Cross, London, N.1, have issued catalogues describing a new hand-operated generator system for controlling distant points and signals electrically.

Motor-Car Lamps.—A lens, called the Parabolite, for improving the distribution of the beam of light thrown ahead from the lamps of road vehicles is described in circulars issued by the manufacturers, Messrs. Miles F. Bingham, 60, Holborn-viaduct, E.C.1.

Roller Bearings.—Messrs. Delco-Remy and Hyatt, Limited, 56, Victoria-street, London, S.W., have issued a leaf catalogue illustrating, by line drawings, the design of their bearings for fan pulleys and rocker arms and for a light type of rear axle for motor cars.

Hoisting Blocks.— A card illustrating applications of their electric hoisting blocks with hand traverse for running on overhead joists, is to hand from Messrs. Herbert Morris, Limited, Loughborough. Prices are quoted for half-ton to five-ton blocks.

Coolers.—A catalogue of mechanical coolers for dealing with air, water, oil, &c., is to hand from Messrs. Heenan and Froude, Limited, Worcester. This catalogue is of special value on account of the practical explanation it gives of the various applications of the cooler.

Electric Light Sets.— We have received from Messrs. Petters, Limited, Yeovil, a fully descriptive catalogue of their small petrol or paraffin engine and generator sets, which are made in several sizes suitable for country houses in which from 50 to 150 lights are installed.

Electric Generators.—A new and revised edition of their catalogue of alternating-current generators of the open type has come to hand from Messrs. Bruce Peebles and Co., Limited, Edinburgh. Several illustrations are given of machines installed in various industries, and full dimensions and technical particulars are included of 50-cycle and 25-cycle machines for three different voltage ranges.

Steam Turbines.—A catalogue of steam turbines of the pure impulse type for mill drives and geared electric drives of moderate powers is to hand from Messrs. Hick Hargreaves and Co., Limited, Bolton. The descriptive matter is clear and practical and the line drawings excellent. Pass-out and back-pressure turbines are also referred to. The ordinary mill-drive type with small diameter rope pulleys and single-reduction gear forms a very compact and well protected power unit.

Machine Tools.—A catalogue of machine tools, the products of six associated German firms, has come to hand from the United Machine Tool Company, Limited, 14, Holborn Hall, Gray's Inn-road, London, W.C. The machines include all the standard types of high-speed lathes from 7 in. to 27½-in. centres, surfacing lathes up to 16 ft. 6 in. swing, shaping machines, milling machines, horizontal boring machines and vertical turning and boring mills, drilling machines, slotting machines, relieving lathes, thread and worm-milling machines, grinding machines, gear-hobbing machines, &c.

Contractors' Plant.—A new issue of their very complete and well-arranged catalogue of lifting machinery and contractors' plant is to hand from Messrs. Richard C. Gibbins and Co., Berkley-street, Birmingham. Cranes are classed under separate headings including steam, electric, railway, workshop, wharf, goliath, overhead, forge, foundry and warehouse types. A number of crabs for hand, belt and direct electric motor drive are also dealt with, and other sections give particulars of jacks, pile drivers, pulley blocks, sheer legs, plate-layers' tools, &c. Prices are generally stated.

Oil-Tank Ships.—A most interesting pamphlet giving much information on the subject of the expansion of the oil trade and the development of special types of ships for carrying oil in bulk has been published by Messrs. Swan, Hunter and Wigham Richardson, Limited, Walls-end-on-Tyne. During the last twenty-five years, the firm has built over sixty of these ships, with steam or oil engines for propulsion and having a total carrying capacity of over 336,700 tons. Illustrations of many of these ships are given with an account of the special features of their construction. A world-map of oil depots is also included.

Sugar Cane Mill Machinery.—An extensive list of parts of the machinery equipment of cane sugar mills has reached us from Messrs. Mirrlees Watson and Co., Limited, Scotland-street, Glasgow. The parts listed amount to about 450 in number, including various forms of the same essential part. All are clearly described with code word and number, and in all necessary cases illustrations are given in the margin. The illustrations are all perspective drawings printed from line blocks and they are very clear and effective. The catalogue is especially satisfactory as a proof that engineering firms are giving careful and highly competent attention to maintaining and extending valuable export trade.

Steam Turbines.—A new catalogue of steam turbines containing a large amount of valuable information has been issued by the English Electric Co., Limited, Queen's House, Kingsway, London, W.C. The introduction states that the standard sizes run at speeds of 6,000 r.p.m., 3,000 r.p.m. and 1,500 r.p.m., these machines covering outputs of 250 kw. to 40,000 kw., and that while the majority of land turbines are applied to driving alternators directly many are used for driving continuous-current generators and alternators of small output through gearing and also blowers, pumps, booster sets, line shafting in mills, &c. The catalogue explains the impulse and reaction types, pointing out the special advantages and applications of each, and this section is followed by a general description under sub-headings such as casings, nozzles, diaphragms, rotors, blading, shaft glands, thrust blocks, lubrication, bearings, couplings, and governing gear. Reducing turbines for use in works in which a large amount of low-pressure steam is consumed in heating and manufacturing processes are briefly mentioned. In addition to several illustrations of turbines supplied for various purposes there are many excellent sectional line illustrations, and also illustrations of parts corresponding to the sub-headings mentioned above. Engineers will find this catalogue of exceptional interest.

STANDARD SPECIFICATION FOR COPPER PLATE, RODS, &C.—A specification, No. 24, Part 5, 1925, has been issued by the British Engineering Standards Association, dealing with copper plates, rods, tubes, pipes, and brass tubes for railway rolling-stock. This supersedes those numbered 11, 12, and 12A, issued last year, which concerned copper plates for locomotive fire-boxes and rolled and extruded copper rods for locomotive stay bolts, rivets, &c. The pamphlet contains also requirements with regard to brass and copper tubes for boilers and seamless copper pipes for railway engines. The principal modifications made to the brass and copper tube and pipe specifications consist of the tolerances allowed on lengths, thicknesses, and external diameters, together with the insertion of a tensile test and the alteration of the copper and arsenic contents in the copper tube and pipe specifications to permit of the analyses being made the same for all copper manufactures dealt with in the latest issue. As is customary, an appendix is supplied at the end of the leaflet which gives dimensioned drawings of the forms of the different regulation test pieces. Copies of the specification may be had from the B.E.S.A. Publications Department, 28, Victoria-street, Westminster, London, S.W.1, price 1s. 2d. each, post free.

CUTTING TOOLS RESEARCH.

Fig. 10. LINES OF PRINCIPAL STRESS IN WORK WHEN TWO TEETH OF A MILLING CUTTER ARE OPERATING.

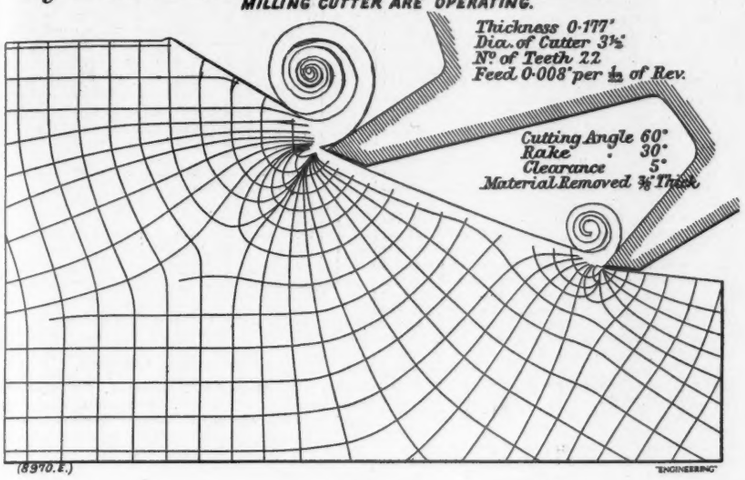


Fig. 11. CONTOUR STRESSES IN WORK DUE TO THE ACTION OF TWO TEETH OF A MILLING CUTTER.

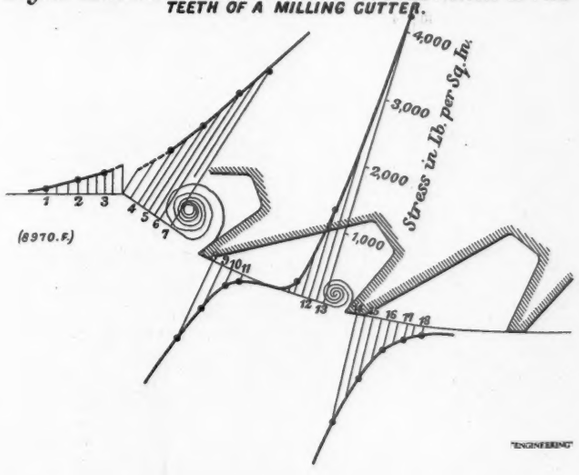
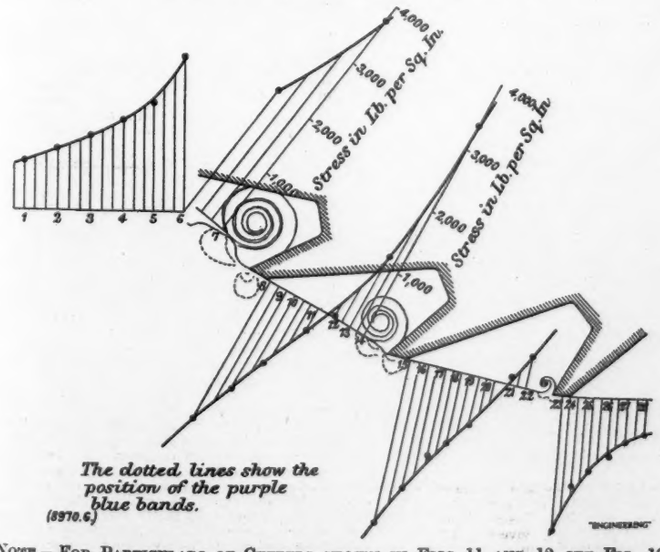


Fig. 12. CONTOUR STRESSES IN WORK WHEN THREE TEETH OF A MILLING CUTTER ARE ACTING.



NOTE.—FOR PARTICULARS OF CUTTERS SHOWN IN FIGS. 11 AND 12, SEE FIG. 10. DEPTH OF MATERIAL REMOVED IN FIG. 11, $\frac{3}{8}$ IN.; IN FIG. 12, $\frac{9}{16}$ IN.

CUTTING TOOLS RESEARCH COMMITTEE.

REPORT ON THE ACTION OF CUTTING TOOLS.*

BY PROFESSOR E. G. COKER, D.Sc., F.R.S.

(*Concluded from page* 364.)

Milling Cutters.—The most obvious feature of difference presented by the action of a milling cutter is that the shaving removed is no longer uniform, as in the case of planing and turning tools, but gradually increases in thickness as the cut proceeds. This is due to the fact that each tooth point describes in general an oblate trochoidal curve due to the combined action of the rotation and feed. The behaviour of such cutters when at work presents some features of interest which are not present in the forms of tool action already described. These features are mainly due to the action of neighbouring cutters, each taking cuts of different thickness simultaneously. It has already been shown that the isolated action of a single cutter produces stress which is approximately radial with respect to the cutting edge of the tool, falls rapidly in intensity as the distance from the cutting edge increases, and varies in sign according to the radial direction taken. In general, as we have seen, the whole of the area in front of the black brush springing from the point of the tool is in compression and the part behind it is in tension. But since there are now two or more cutting edges in action, there ought in general be some region between two consecutive teeth where the pull of the one tooth is neutralised by the push of the one advancing behind it, and this is confirmed by experiment. At and near the contour a black patch is found between each pair of teeth, which does not in general remain in a stationary position as the cut advances, owing to simultaneous changes at consecutive cutting edges which do not vary in the same manner.

The general phenomena observed is that the characteristic colour bands described in relation to other tools also occur here, although indicating possibly somewhat more complex stress distribution. The black patches between each pair of teeth are also indicated, while the characteristic markings on the shavings show that the material is being torn or wedged off by the action of the cutter.

The isoclinic lines observed when the foremost tooth is not far from the end of its cut, are curves which indicate that the black brush separating compression and tension areas does not remain in the same direction with respect to the contour as the cutting edge advances. It is nearly perpendicular to the contour for the lower tooth, while at the upper tooth it is now about 20 deg. in advance of its former position. This is characteristic of this type of cutting action. Most of the intermediate isoclinics converge to a small area bounded by the contour where the black patch is observed, thereby affording a confirmation of the view that this latter is really a place of no stress and not a place where two principal stresses of equal and like magnitude exist, which latter stresses would give the same black area, but not the convergence of the isoclinics indicated. The lines of principal stress drawn from the data obtained are shown in Fig. 10, and attention is drawn to the way in which those in front of each cutting edge thread into the corresponding shaving, where they are lost track of owing to the permanent overstress there destroying the optical character of the material.

Examination of the stress along the contour, Fig. 11, shows the very rapid change from compression to tension which occurs, and it will be noticed here that the stress distribution is not a linear function along the edge, and that as the cut progresses the place of zero stress is pushed forward in relation to the edge in front of it. It has, in fact, a positive relative motion with respect to the cutter periphery. The amount of the stress at any point may be obtained by the scale given in the figure. A number of observations have been made with this cutter when three teeth are engaged simultaneously and the stress distribution at the cut surface is shown in Fig. 12. The progressive advance of the place of zero stress as the cut proceeds is very marked, and this effect is no doubt due to the increasing pressure imposed on the point of the tool. When the cut is nearly finished the vertical face of the plate also becomes stressed in a very marked and complex manner, and finally a part is entirely pushed off in the same manner as occurs in the cutting of metals. Photo-elastic investigation of the action of cutting tools has now reached a stage at which there is a reasonable prospect of further development if certain fundamental investigations are carried out.

* Presented at the meeting of the Institution of Mechanical Engineers, on Friday, March 13, 1925. Abridged.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

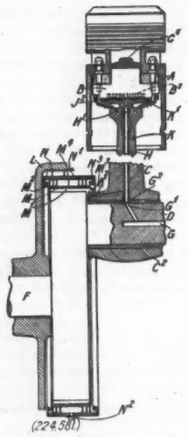
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C.2, at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

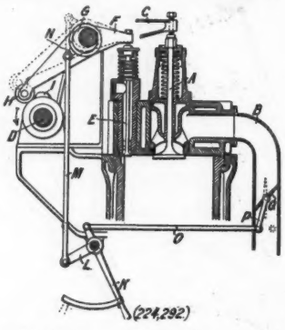
GAS ENGINES, PRODUCERS, HOLDERS, &c.

224,581. W. Beardmore, Lord Invernairn, Westminster, London, and A. E. L. Chorlton, Westminster, London. Internal-Combustion Engines. (2 *Figs.*) July 18, 1923.—The invention relates to lubricating systems for internal-combustion engines employing crank-case compression. In the system, according to the invention, the lubricant is supplied to the bearing between the piston and the connecting rod and is returned therefrom to a collecting device in the crank-case, the supply and return passages for the lubricant and the collecting device being so arranged as to form a substantially closed circuit. The piston A has fixed to it a bearing member B, which is so arranged as to have the whole of its lower surface available as a bearing surface whilst its upper surface is cut away at each end to enable it to be secured to the piston A. The connecting rod C is provided at its upper end with a strap C^1, which is shaped to engage with the bearing member B. The lower end of the connecting rod C is also provided with a strap C^2 surrounding the crank-pin D, which is connected in the usual manner by crank webs to the crankshaft F. The lubricating oil is forced by a pump through a passage G in the crankshaft and the crank-pin to an outlet G^1 in the surface of the crank-pin. Registering with this outlet G^1 is a groove G^2 in the bearing surface of the strap C^2 extending part of the way round the crank-pin D. This groove G^2 communicates with a central passage H in the connecting rod C. At the upper end of the rod this passage H connects with a passage H^1 in the strap C^1 leading to the lower surface of the bearing member B. The oil is thus forced from the



crankshaft through the passage H in the connecting rod to the bearing member B. The oil then works across the bearing surface towards the ends of the bearing member, grooves B^1 being provided in this member to distribute the oil over the surface of the bearing. To prevent the oil from flowing out at the top between the strap C^1 and the bearing member B, scrapers are provided in the strap, these scrapers being pressed against the surface of the bearing member by springs. The oil is caught at the ends of the bearing member by flanges J^2 on the strap C^1, and is returned through passages K^1 in the strap to a second passage K in the connecting rod concentrically surrounding the central supply passage H. One or each of the crank webs is extended into the form of a disc disposed centrally within the crank-case L, and an annular box M is mounted on this disc in such a manner as to leave an oil passage M^1 between the edge of the disc and the box. A number of vanes M^2 project outwards from this box M opposite to another set of vanes N^1 projecting inwards from a collecting ring N fixed to the crank-case wall L and surrounding the annular box M. The ring N is provided at its edges with troughs N^3 to catch any oil outside the vanes N^1. The collecting ring N has an outlet passage N^2 at the bottom leading to an oil sump outside the crank-case L. The annular box M has a lip M^3 projecting inwards on the side adjacent to the crank-pin D. This lip M^3 does not extend around the whole circumference of the box M, but is provided only at that part of the box which is close to the crank-pin. The return passage K for the oil through the connecting rod C communicates with an outlet K^2, which lies under the lip M^3, so that the oil is thrown centrifugally outwards from the outlet and is caught by the lip and passed into the interior of the box M. The strap C^2 has sharp flanges C^3 at its end to ensure that the oil is caught by the lip M^3. One or more openings M^4 are provided in the box M which allow the oil to pass through to the outside and to be thrown centrifugally into the collecting ring N, whence it drains away through the passage N^2 into the sump. This arrangement in effect provides a closed lubricating system, so as practically to prevent any oil from escaping to be carried from the crank-case into the cylinder with the air charge. (*Sealed.*)

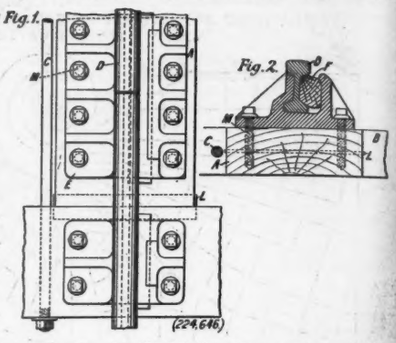
224,292. The Hon. Sir C. A. Parsons, Newcastle-upon-Tyne, S. S. Cook, Newcastle-upon-Tyne, and H. G. Kimber, Newcastle-upon-Tyne. Internal-Combustion Engines. (2 *Figs.*) August 8, 1923.—The invention relates to devices employing steam for starting internal-combustion engines. The invention consists in a device for starting internal-combustion engines in which a steam valve is brought into operation by means of a single mechanism which also brings into operation means for reducing the compression in the cylinder either by restricting the flow of air to the air valve or by delaying the closing of the air valve. The head of the working cylinder is provided with an air admission valve A and air duct B leading thereto, the valve A being operated by the rocking lever C actuated by a cam mounted upon a cam shaft D. In addition to this, a small steam valve E is provided in the cylinder head operated by one end of a rocker F mounted on an eccentric G, which can be rotated and forms its fulcrum. This rocker F is provided at the other end with a roller H which engages with a cam I mounted on the camshaft D. The eccentric G may be partially rotated by means of a control lever K, which is adapted to be moved into the "running" or into the "starting" position and is connected to the eccentric G by means of a lever arm L, a link M and a lever arm N fixed to the eccentric. The rotation of the eccentric G moves the roller H into or out of contact with the cam I, the "running" position being that in which the rocking lever is removed from engagement with the cam, as



shown in dotted lines. Where the pressure of the available steam is less than the pressure to which air is normally compressed in the working cylinder, steam would only be admitted during that portion of the stroke when the pressure in the cylinder had fallen below the pressure of the steam. In such cases, and in cases where the steam pressure is not sufficiently in excess of the pressure to which air is normally compressed in the working cylinder, means are provided for regulating the pressure in the cylinder immediately prior to the admission of steam. This is effected by interconnecting the control lever K with a throttle valve Q situated in the air duct B by means of a link O and lever arm P. This throttle valve is so arranged that when the control lever is moved into the "starting" position, the throttle valve is closed so as to restrict the passage of the air to the cylinder and the roller on the rocking lever is brought into contact with the cam. The "starting" position is shown in full lines. In this position of the control lever, steam will be admitted to the cylinder by the operation of the cam while a very small quantity of air will only be admitted to the cylinder, due to the restriction of the throttle valve. When the engine has been running sufficiently to gain the required momentum the control lever is thrown over to the "running" position. This movement of the control lever opens wide the throttle valve in the air duct and removes the rocking lever from contact with the cam, so that further steam is not admitted to the cylinder. The engine will now function in the ordinary way. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

224,646. Sir B. Leslie, London. Railway Rail Joint. (4 *Figs.*) September 6, 1923.—The invention relates to joints and supports for the ends of railway rails. An inflexible support for the rail ends consists of a short longitudinal sleeper or joint block A combined with the transverse sleepers B, one on either side of the joint, the longitudinal sleeper or joint block extending between and at the same level as the transverse sleepers B and being rigidly connected therewith by means of tongue plates L. The longitudinal sleeper or joint block A is held in firm contact with the transverse sleepers B by means of bolts C, which are adapted to be screwed up tightly and prevent movement between the sleepers. The longitudinal sleeper or joint block would be preferably wider than the transverse sleepers and arranged so that the whole platform is readily accessible from all sides and constitutes an inflexible support for the rigid rail ends. The rails D are carried in cast-iron joint chairs E fastened to the longitudinal sleeper A by means of screws M, the bases of which chairs are wide enough to afford support to the rails. The jaws of the joint chairs may be increased in width if desired. Hard wood or



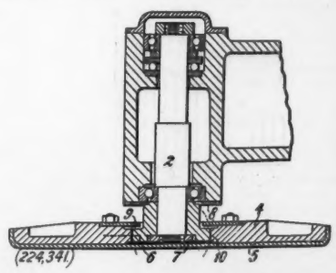
other suitable wedges F may be interposed between the jaws of the chairs and the rails to hold them in position. (*Sealed.*)

MISCELLANEOUS.

223,371. Bromford, Limited, Aston, Birmingham, and J. Reimann, Erdington, Birmingham. Joints for Wrought Metal Tubes. (3 *Figs.*) September 12, 1923.—The invention relates to wrought metal tubes of the kind provided with integrally-formed

external flanges or collars. According to the invention, a flange or shoulder B^3 is formed on a tube B by turning the end of the tube B^2 back and firmly compressing it upon a liner or sleeve A located upon the outside of the tube. (*Sealed.*)

224,341. Pilkington Brothers, Limited, St. Helens, and F. B. Waldron, Prescot. Polishing Glass Plates. (1 *Fig.*) August 26, 1923.—The invention relates to apparatus for polishing plates of glass, and more particularly to that type of polishing apparatus in which a number of polishing blocks, each adapted to rotate about its own axis, is mounted on a framework which rotates about its axis. According to the invention, each polishing block 4 is mounted loosely on its stub spindle 2 so that it is free to rest evenly on the surface of the glass by its own weight, and the contact between the stub spindle 2 and the block 4, whereby the latter is held against centrifugal force, is in a plane which is parallel to the operative face of the block and passes approximately through the centre of gravity of the block or between the centre of gravity and the operative face of the block. The polishing block 4, covered with a



felt 5, is mounted on a boss 6, which is attached to the end of the stub spindle 2 by means of a nut 7. The boss 6 fits loosely in a cylindrical hole in the polishing block 4 and is capable of a small vertical movement therein, which is limited in an upward direction by a plate 8 attached to the block, engaging with a shoulder 9 on the boss 6. By means of the shoulder 9 and plate 8, the block 4 may be lifted clear of the glass by raising the framework of the runner. In operation, the runner framework is lowered, so that when the block 4 rests on the glass, the boss 6 is clear of the plate 8, as shown in the drawing. The periphery 10 of the boss 6, where it makes contact with the block 4, is curved, preferably to a portion of a sphere, so that it may make contact with the block 4 only along a line and so that the block 4 may tilt on the boss 6 when required to take an even bearing on the glass. (*Sealed.*)